THE PHILIPPINE
JOURNAL OF SCIENCE

VOL. 53 MARCH, 1934 No. 3

THE NUTRITIVE VALUE OF THE MOUNTAIN APPLE EUGENIA MALACCENSIS OR JAMBOSA MALACCENSIS [1]

By CAREY D. MILLER, RUTH C. ROBBINS, and KISAKO HAIDA

Of the Nutrition Laboratory, Hawaii Agricultural Experiment Station, under the joint supervision of the University of Hawaii and the United States Department of Agriculture, Honolulu

ONE PLATE AND THREE TEXT FIGURES

The mountain apple, *Eugenia malaccensis* or *Jambosa malaccensis,* is a fruit tree indigenous to the tropical Pacific islands and northern Australia. It was probably brought to the Hawaiian Islands by the early Polynesians and is called by the Hawaiians *ohia-ai.*

In the Hawaiian Islands, its distribution was previously much greater than now, as in some places it has been cut and in others it has died because the water supply has been diverted for agricultural purposes. From almost sea level up to 1,800 feet, the mountain apple is found growing in thick stands along the streams of sheltered valleys, especially on the windward slopes.

Many of the present trees are rather small, but they vary in height from 25 to 50 feet and have beautiful, dense green foliage and bright crimson flowers. The corolla and calyx of the flowers are insignificant in comparison with the pistil and mass of stamens. The flowers and fruit borne on thick short stems, grow from the trunks as well as from the branches. The fruit resembles an apple but tends to be somewhat pear-shaped (Plate

---

[1] Published with the permission of the director of the Hawaii Agricultural Experiment Station.

1). It has a thin and delicate skin of a deep crimson color and a crisp, snowy white pulp of mild flavor. There is usually a single round seed, which is covered with a brown skin. The edible portion of the mountain apple varies from 73 to 87 per cent, some of the fruits having much larger seeds than others. The fruit may be used fresh, for making fruit juices, in salads, and in cooked dishes, such as pie. Ripe fruit can usually be obtained from some part of the Hawaiian Islands from June to October, but it is usually most plentiful during July and August. Small quantities of fruit are sometimes obtainable at other times of the year.

Many inquiries have come to the nutrition laboratory of the University of Hawaii regarding the nutritive value of the mountain apple. The work here reported has been done to supply information locally, but because of the wide distribution of this fruit it is believed it will be of interest to others.

COMPOSITION

The nutritive constituents, total acidity, and mineral elements of the fruit were determined by the methods of the Association of Official Agricultural Chemists(1) or by slight modifications of these procedures. Acid was calculated as anhydrous citric and is reported as percentage of the fresh substance. Iron was determined by the method recommended by Elvehjem and Hart.(2)

Samples for all analyses except iron and total acidity were prepared by wiping the mountain apples carefully and slicing without peeling. The stones were discarded, and the sliced edible portion was dried on enamel trays in an enamel-lined electric oven at a temperature below 65° C.

In being prepared for the iron analyses the mountain apples were peeled and cut with a new stainless-steel knife and ashed wet to avoid contamination. Separate determinations were made on the skin and on the pulp. The percentage of iron given in the table is the average of three sets of analyses; in each case the skin and the pulp were analyzed separately, and the results added. For the determination of total acidity fresh fruit was used.

The average amounts of the other constituents, obtained by analyses of two different lots of mountain apples, are summarized in Table 1, together with a previously published analysis by the Hawaii Agricultural Experiment Station.(3) The analyses show the mountain apple to be a watery fruit with about half the sugar content of apples, and a similar amount of calcium, phosphorus, and iron.(4) Practically all of the iron is in the skin. We found that if the red skin was completely removed, the colorimetric readings for the iron of the pulp were the same as the blank determinations.

TABLE 1.—*Composition of the fruit of mountain apple.*

Constituent.	Average of two analyses. Nutrition laboratory.	From Report of the Hawaii Agr. Expt. Station, 1914.
	Per cent.	*Per cent.*
Moisture	91.54	91.39
Protein (N × 6.25)	0.33	0.213
Ether extract	0.06	0.035
Crude fiber	0.80	0.562
Ash	0.26	0.137
Carbohydrate by difference	7.01	
Acid as citric	0.15	
Reducing sugars		6.88
Sucrose		None.
Calcium	0.007	
Phosphorus	0.013	
Iron	0.00038	

Although analyses show the fruit to have a high water content, it does not seem very juicy when cut. This is perhaps due to the nature of the polysaccharide present. The crude fiber, when determined by the usual methods, was found to swell much more than would be expected if it were ordinary cellulose, and to have a remarkable power of holding water. The nature of this crude fiber would bear further investigation.

The coloring matter in the skin also would be an interesting subject for investigation. It stains a deep purple everything with which it comes in contact. A dilute solution of the juice from the whole fruit prepared for the acidity determination showed a strong indicator action. The solution was distinctly pink when acid and greenish yellow when alkaline, with a definite end point.

VITAMIN METHODS

The methods used for the quantitative determination of the vitamins were essentially those recommended by Sherman.(4) The rats were standard animals raised in our laboratory. All the usual precautions recommended for carrying out quantitative vitamin tests were followed.

Because of the short season and the uncertainty of a continuous supply of fresh fruit, the experiments here reported were done over a period of three years. Most of the experiments carried on during the first summer were of a preliminary nature and are not reported in the final summaries.

The term "daily feedings" is here used to mean feedings given every day except Sunday.

VITAMIN A

Table 2 and fig. 1 summarize the results of feeding mountain apple as the sole source of vitamin A to twenty-six standard white rats.

TABLE 2.—*Results of feeding mountain apple as the sole source of vitamins A, B, and G.*

VITAMIN A.

Source of vitamin.	Rats.	Weight of supplement fed daily.	Average weights.			Average gain or loss in eight weeks.
			Initial.	When supplement started.	Final.	
		g.	*g.*	*g.*	*g.*	*g.*
Negative control	2	0.0	38	----------	89	----------
Mountain apple	9	4.0	43	157	139	[a]—18
Do	10	6.0	43	158	197	39
Do	3	8.0	45	135	165	30
Do	4	10.0	40	120	165	45
VITAMIN B.						
Negative control	2	0.0	58	----------	52	----------
Mountain apple	17	8.0	56	81	102	21
VITAMIN G.						
Negative control	2	0.0	56	----------	70	----------
Mountain apple	8	8.0	52	71	110	39
Do	8	10.0	52	69	110	41

[a] Fed only five weeks.

The mountain apple is obviously low in vitamin A. Rats fed, respectively, 6, 8, and 10 grams of mountain apple daily grew rapidly at almost the same rate for four weeks and then started to lose weight. Four animals on 6 grams daily died at the end of five or six weeks, whereas the remaining group of animals stopped losing or gained again. There was no apparent change in the quality of the fruit at this time, and accordingly there is no simple explanation of this response of the rats to the feeding procedure. The four rats fed 10 grams of mountain apple daily showed poor growth response the last four weeks, but their average gain for eight weeks was greater than the average gain of the groups fed 6 and 8 grams daily.

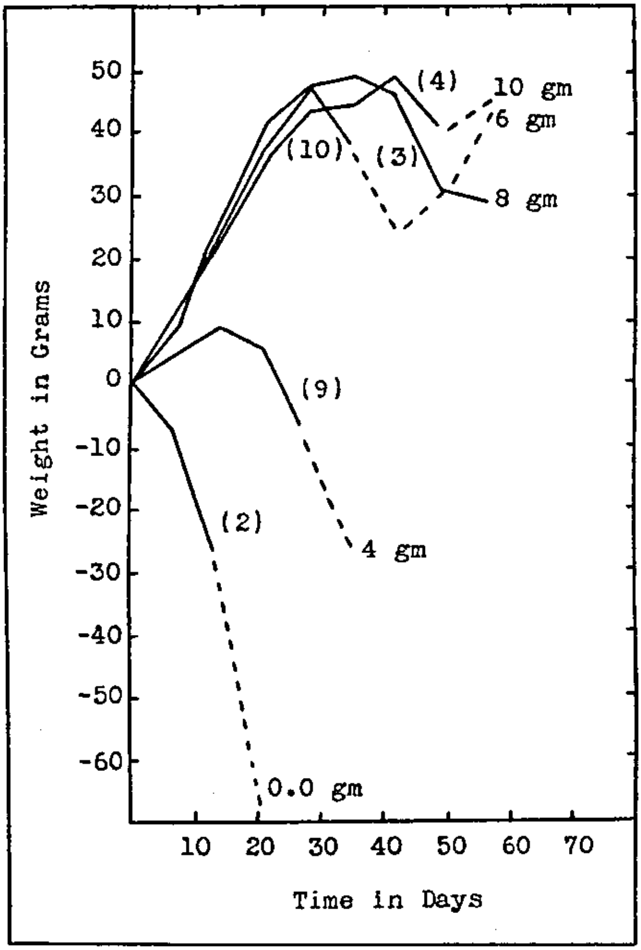


FIG. 1. Average gain in weight of groups of young rats fed varying quantities of mountain apple, *Eugenia malaccensis*, as the sole source of vitamin A. The numbers in parentheses show the number of rats used for each test. The broken lines begin at a point indicating the occurrence of the first death in the group.

Many of the rats showed an unsteady gait with a tendency to drag the hind legs. At autopsy the rats were found to have good stores of fat in the abdominal cavity, but many symptoms of A avitaminosis were usually present. Some showed swollen eyelids with or without bloody exudate, and some showed kidney and bladder infection. Infection of the lungs and air passages and pus at the base of the tongue was observed in some rats. On gross autopsy, the females usually showed well-developed ovaries with large ripe follicles, whereas the males showed poor sexual development. The testes were often small, and even when of nearly normal size, were abnormally dark in color. Upon microscopic examination, no motile sperms were found and in only a few were mature sperms seen.

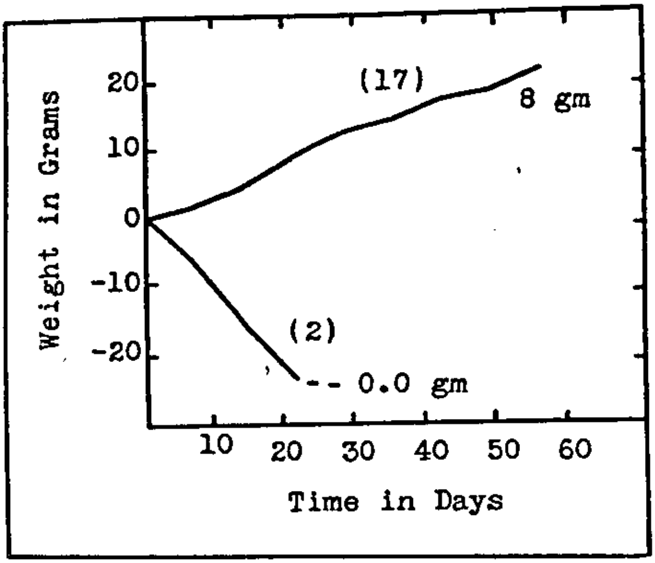


FIG. 2. Average gain in weight of young rats fed 8 grams of mountain apple, *Eugenia malaccensis*, as the sole source of vitamin B (B_1). The broken line indicates the occurrence of the first death in the control group. The numbers in parentheses show the number of rats used for the tests.

VITAMIN B

Only the final tests are reported here. The results of feeding seventeen standard rats 8 grams of mountain apple daily as the sole source of vitamin B are summarized in Table 2 and fig. 2.

The average gain in eight weeks for the seventeen rats was 21 grams, but there was a great variation in the individual gains. Two rats lost 3 and 9 grams, respectively. The smallest gain was 6 grams and the greatest gain 38 grams.

At autopsy most of the rats appeared small but normal. The females showed poor sexual development; in all cases the vaginal orifices were closed and the ovaries were small or only slightly developed. On the other hand, the males all showed well-developed testes and, upon microscopic examination, great quantities of motile sperms. These are exactly opposite to the conditions found at autopsy of the rats on vitamin-A experiments.

The mountain apple is therefore observed to be only a fair source of vitamin B.

VITAMIN G

The final results of feeding sixteen standard rats 8- and 10-gram supplements of mountain apple daily as the sole source of vitamin G are summarized in Table 2 and fig. 3.

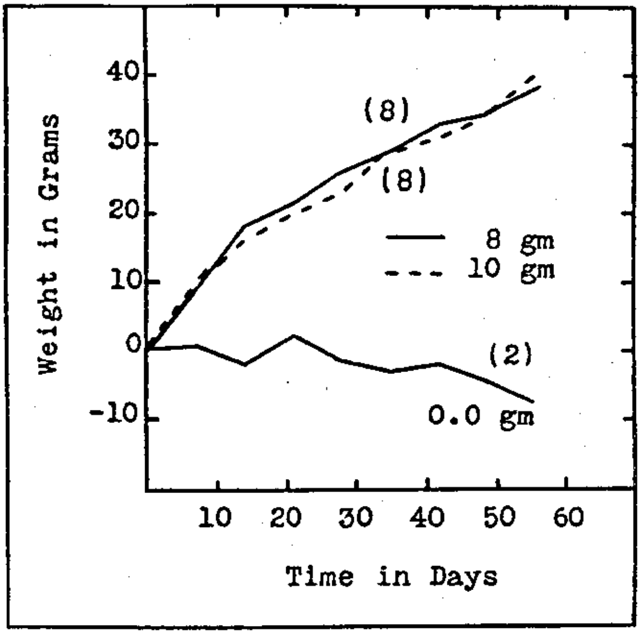


FIG. 3. Average gain in weight of groups of young rats fed 8 and 10 grams of mountain apple, *Eugenia malaccensis*, as the sole source of vitamin G (B_2). The numbers in parentheses show the number of rats used for each test.

The rats in each group gained much more uniformly than those fed for vitamin B, but there was little difference in the two groups. The average gain in eight weeks for eight rats fed 8 grams of mountain apple daily was 39 grams, and that for eight rats fed 10 grams daily was 41 grams.

At autopsy all the rats showed some evidence of G avitaminosis. In our laboratory mild symptoms of low vitamin-G intake are an abnormally short, soft fur, which in some cases is thin around the head and shoulders; blood on nose, paws, and ears, which comes from the hair follicles at the base of the whiskers; and poor sexual development. Two rats fed 10 grams of mountain apple daily showed slight necrosis of the end of their tails. Two rats in each group showed a few very small lesions. Only two male rats, one in each group, showed any motile sperms. Five female rats showed no ripe follicles, and five showed ripening or well-developed follicles. As the rats averaged 110 grams when killed, the sexual development may be related to growth and only indirectly to low vitamin G.

It thus appears that mountain apples are a fair source of vitamin G.

VITAMIN C

Twenty-two standard guinea pigs raised in our laboratory were used to test the vitamin-C potency of mountain apples. The guinea pigs were fed Sherman's(4) scorbutic basal diet plus fresh alfalfa plus the supplements until they ate the mountain apple readily. The alfalfa was then discontinued and the mountain apple fed to the guinea pigs for the periods recorded in Table 3. At the end of the experiment the histological examination of the incisor teeth recommended by Höjer(5) was employed. The results of the experiments are summarized in Table 3.

Five guinea pigs were fed for a period of 90 days (one died after 66 days), seven were fed for 21 days, and ten were fed for 28 days. Of the three guinea pigs fed 3 grams of mountain apple daily, one died at 66 days and the other two lived out the experimental period of 90 days. All showed severe scurvy at autopsy. The two fed 5 grams for 90 days showed somewhat less severe scurvy, and the four guinea pigs fed 5 grams of mountain apple for 21 days showed slight or moderate scurvy at autopsy. Both guinea pigs fed 10 grams of mountain apple daily for 21 days showed no evidence of scurvy at autopsy. One guinea pig fed 15 grams daily showed no gross scurvy at autopsy, but the teeth were not completely protected. Six guinea pigs were fed 20 grams of mountain apple daily for 28 days and showed no signs of gross scurvy. Three had the teeth completely protected and three only partially protected. Two guinea pigs fed 25 grams of mountain apple daily for 28 days showed no gross scurvy at autopsy, but the teeth were not fully protected. Finally, two guinea pigs fed 30 grams of mountain apple daily for 28 days showed no evidence of scurvy at autopsy and the teeth were normal.

TABLE 3.—*Results of feeding mountain apple as the sole source of vitamin C.*

Guinea pig No.	Weight of supplement fed daily.	Supplement fed.	Weight.		Net gain or loss.	Gross scurvy at autopsy.[a]	Histological examination of teeth, Höjer's rating.[b]
			When supplement started.	At end of experiment.			
	g.	*Days.*	*g.*	*g.*	*g.*		
95M	3	66	359	213	—146	+++	--------------
99M	3	90	347	326	— 21	+++	--------------
103M	3	90	334	285	— 49	+++	--------------
62F	5	21	356	344	— 12	++	0.5
101M	5	21	335	316	— 19	+	0.4
64F	5	21	334	322	— 12	+	0.2
66F	5	21	330	289	— 41	+	0.2
93M	5	90	401	477	76	+++	--------------
97M	5	90	337	423	86	+++	--------------
68F	10	21	308	295	— 13	—	0.7
70F	10	21	302	304	2	—	0.7
72F	15	21	306	313	7	—	0.7
160F	20	28	300	367	67	—	1.0
162F	20	28	304	361	57	—	1.0
164F	20	28	307	282	— 25	—	0.7
166F	20	28	315	380	65	—	0.7
168F	20	28	315	421	106	—	1.0
181M	20	28	385	496	111	—	0.8
170F	25	28	312	286	— 26	—	0.8
179M	25	28	309	330	21	—	0.7
172F	30	28	279	388	109	—	1.0
183M	30	28	319	374	55	—	1.0

[a] Sherman and Smith, The Vitamins, 2d ed., 173. [b] Höjer (see bibliography).

The results indicate that the mountain apple is of relatively low antiscorbutic value.

SUMMARY AND CONCLUSIONS

The mountain apple, *Eugenia malaccensis* or *Jambosa malaccensis,* a refreshing fruit of the tropical islands of the Pacific Ocean, has been analyzed for nutritive constituents and tested for its vitamin value.

Comparison of analyses given in Table 1 with analyses given by Sherman (4) shows that mountain apples have about half the sugar content of average apples and a higher water content than apples. The amounts of calcium, phosphorus, and iron are similar in both fruits.

Comparison of the data for mountain apples with data given by Sherman (4) for apples indicates that mountain apples are somewhat lower in all the vitamins tested and can be considered only a fair source of vitamins A, B, C, and G.

BIBLIOGRAPHY

1. Association of Official Agricultural Chemists. Official and Tentative Methods of Analysis. 3d ed. Washington, D. C. (1930).
2. ELVEHJEM, C. A., and F. B. HART. Journ. Biol. Chem. 67 (1926) 43.
3. Report of the Hawaii Agricultural Experiment Station (1914) 67.
4. SHERMAN, H. C. Chemistry of Food and Nutrition. Macmillan Company, New York. 4th ed. (1932).
5. HÖJER, A. Brit. Journ. Exp. Path. 7 (1926) 356.

ILLUSTRATIONS

PLATE 1. Mountain apple; *Eugenia malaccensis.*

TEXT FIGURES

FIG. 1. Average gain in weight of groups of young rats fed varying quantities of mountain apple, *Eugenia malaccensis,* as the sole source of vitamin A. The numbers in parentheses show the number of rats used for each test. The broken lines begin at a point indicating the occurrence of the first death in the group.

2. Average gain in weight of young rats fed 8 grams of mountain apple, *Eugenia malaccensis,* as the sole source of vitamin B (B_1). The broken line indicates the occurrence of the first death in the control group. The numbers in parentheses show the number of rats used for the tests.

3. Average gain in weight of groups of young rats fed 8 and 10 grams of mountain apple, *Eugenia malaccensis,* as the sole source of vitamin G (B_2). The numbers in parentheses show the number of rats used for each test.

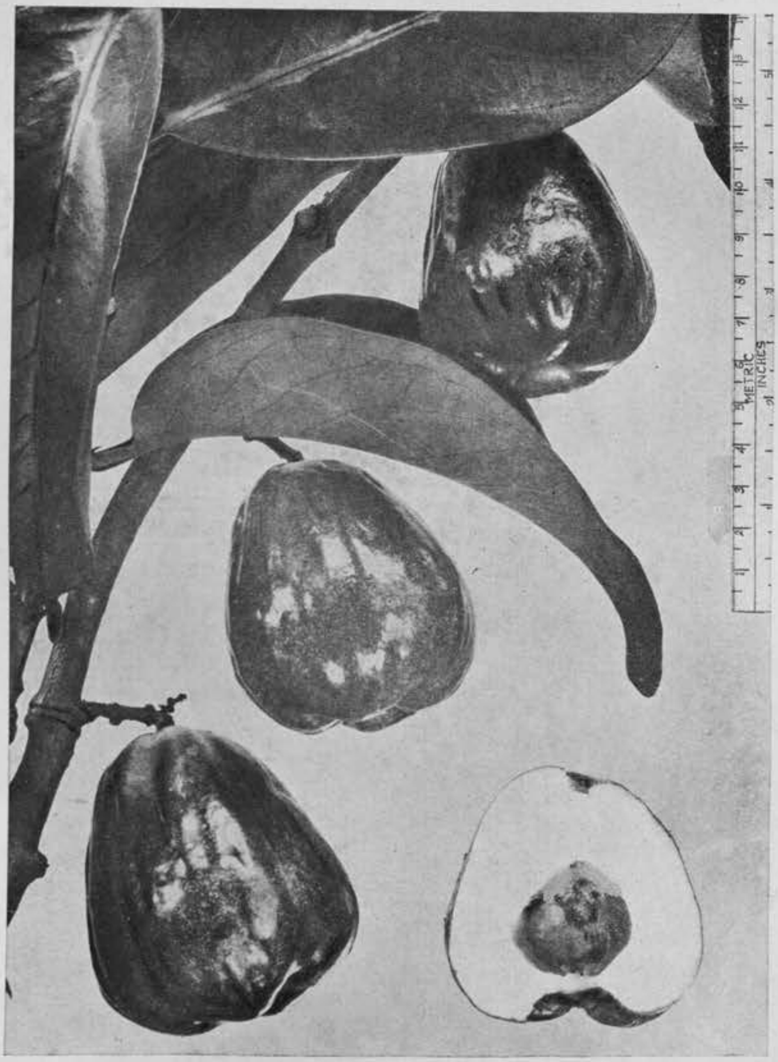


PLATE 1.

LEPIOTA AMERICANA, AN IMMIGRANT EDIBLE MUSHROOM

By José Miguel Mendoza

Mycologist, National Museum Division, Bureau of Science, Manila

and

Simeona Leus-Palo

Junior Mycologist, National Museum Division, Bureau of Science, Manila

TWO PLATES

Despite the great abundance of mushrooms in the Philippines, only a few have been really tested for their edibility. While some may prove poisonous to some persons, they may prove edible to others. Of the large number of edible mushrooms, a considerable quantity goes to waste yearly during the mushroom season for lack of information about them, and the number actually reaching the family table is surprisingly small. This is especially true of the many species of *Lepiota* because some members of this genus are known to be poisonous or of a suspicious character. For example, *Lepiota chlorospora* often causes poisoning in many people, hence the mushroom collector who is familiar with this species looks askance at any mushroom that resembles it. Another species, *Lepiota cepaestipes* Fr.,[1] has been found recently by the senior author to be poisonous. Indeed, because a certain mushroom is known to be poisonous or suspected of being poisonous, the rest of its kind are often erroneously believed to be dangerous. In fact, many, including the numerous species of *Lepiota,* are palatable and safe to eat. We feel, therefore, that those mushrooms that have been found edible, especially the little known species, should be reported from time to time so that their good qualities and other characteristics may become familiar to the people. In this way we hope to add to the short list of edible mushrooms in the Philippines.

LEPIOTA AMERICANA Peck. Plates 1 and 2.

Lepiota americana Peck in New York State Cab. Rept. 23 (1871) 71; Saccardo, Syl. Fung. 5 (1887) 43; Atkinson, Mushrooms (1911) 80, *f. 82;* Murrill, Mycologia 3 (1911) 168, *t. 49, f. 6;* Kauffman, Agaricaceae of Michigan 1 (1918) 645.

---

[1] This poisonous mushroom will be reported in a separate paper.

Pileus[2] white, becoming dark brown on maturity, 5 to 14 cm broad, convex, umbonate to subumbonate at maturity, when young somewhat conical; cuticle at first reddish brown and continuous, soon breaking into scales except at the umbo; scales scattered, appressed; margin somewhat inrolled, striate, laciniate; when bruised entire plant turns pinkish to reddish brown. Gills free, white, broad, 7 to 9 mm wide. Stipe hollow, white, becoming brown in age, enlarged at the base, tapering upward, 6 to 11 cm long, 9 to 15 mm in diameter at the base, slender above the ring, 7 to 10 mm in diameter. Annulus broad, very conspicuous, 1.3 to 2.2 cm wide, 1.6 to 2.5 cm from the pileus. Basidia clavate, granular when young; granules disappearing in age, bearing 4 slender sterigmata, 18 to 30 μ long, 8.4 to 10.5 μ broad, average 24.6 μ long, 9.1 μ wide. Spores subellipsoid guttulate, smooth, hyaline, measuring from 8.5 to 10.5 μ long, 5.0 to 7.2 μ broad, average 9.9 μ long, 6.25 μ broad.

LUZON, Manila, Pandacan, *Bur. Sci. 55119, J. M. Mendoza,* July 29, 1933, on the ground, *Bur. Sci. 55137, 55139, J. M. Mendoza,* July 24, 1933, on the ground, *Bur. Sci. 55209, J. M. Mendoza,* July 25, 1933, on the ground, *Bur. Sci. 55586, J. M. Mendoza,* August 1, 1933, on the ground, *Bur. Sci. 55768, P. S. Gener,* November 7, 1933, on the ground.

Lepiota americana Peck resembles closely in shape a poisonous Philippine species, *L. chlorospora* Copel., particularly in the button stage. *Lepiota chlorospora,* however, has green spores, making the gills look greenish.

This mushroom came to the notice of the senior author in February, 1933, when a sample batch was referred by a member of the staff of the College of Medicine, University of the Philippines, to the Bureau of Science to find out whether or not it was edible. There was doubt in the beginning as to the edibility of this mushroom, since it resembles *Lepiota chlorospora,* which is a poisonous species. The sample was bought in Paco Market, Manila. Following the source of the purchase, it was found that this mushroom had been collected in Pandacan, Manila, in a place which had been filled in with all kinds of refuse, generally mixed with discarded straw and manure taken from United States Army stables. It seems that this mushroom is not well known even in that vicinity, for only one family in that neighborhood collects it in baskets every morning to sell at Paco Market. To test the edibility of this mushroom a few were cooked in the Bureau of Science laboratory. The mushroom was found delicious and a bit peppery. On several occasions later, from time to time, the mushroom was cooked in the laboratory, and several members of the staff ate it with their other food. In taste it is comparable to any of our most delicious mushrooms. This mushroom, because of its white spores unlike *Volvaria esculenta* and *Psaliotas* which have colored spores, has the advantage of not turning the soup black or dark brown on being cooked. It keeps well in the dried form, and when soaked in water before being cooked it somewhat resumes its original form. During the numerous collecting trips made by the senior author, he has never seen this kind of mushroom. Possibly it was accidentally brought into the Philippines from abroad with animal feed, such as hay, for United States Army horses.

---

[2] The following description is based on fresh full-grown specimens collected during the mushroom season.

It is abundant during May to as late as February.

ILLUSTRATIONS

PLATE 1. LEPIOTA AMERICANA PECK

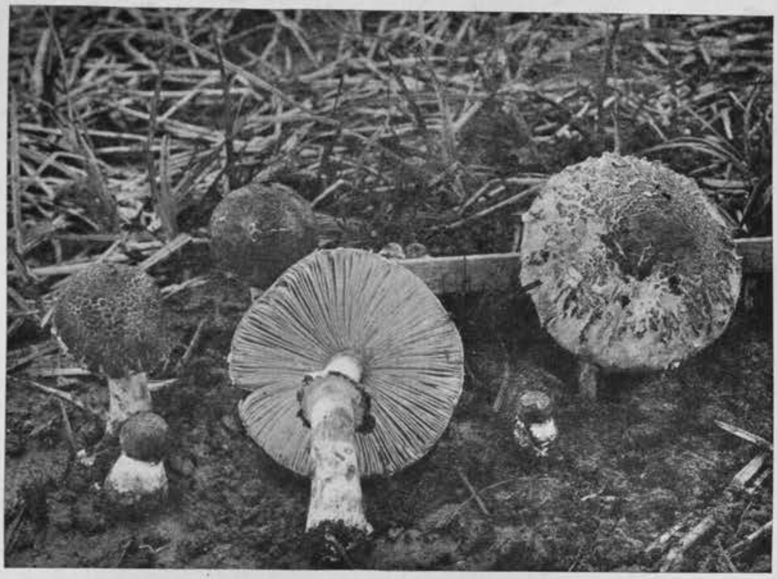
FIG. 1. The mushroom in natural habitat, showing different stages. (Photographed by Domingo Farol of the Bureau of Science.)

2. The mushroom as sorted ready for the market. (Photographed by Domingo Farol of the Bureau of Science.)

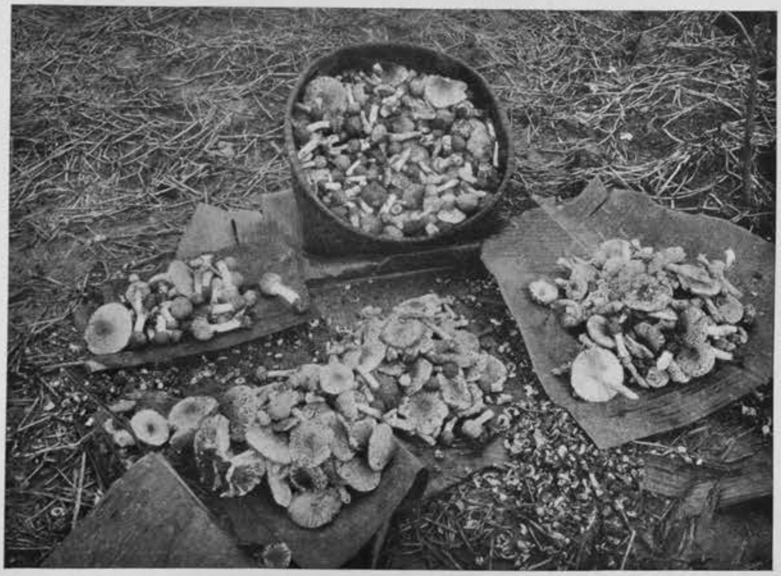
PLATE 2. LEPIOTA AMERICANA PECK

FIG. 1. Photomicrograph of a section of the gill, showing the hymenium with basidia; × 235.

2. Photomicrograph of the spores, from spore collection; × 433.

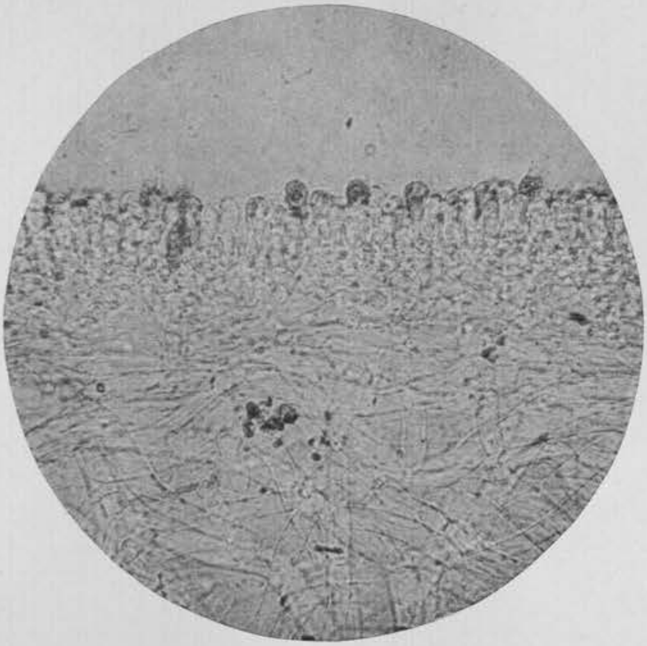


1

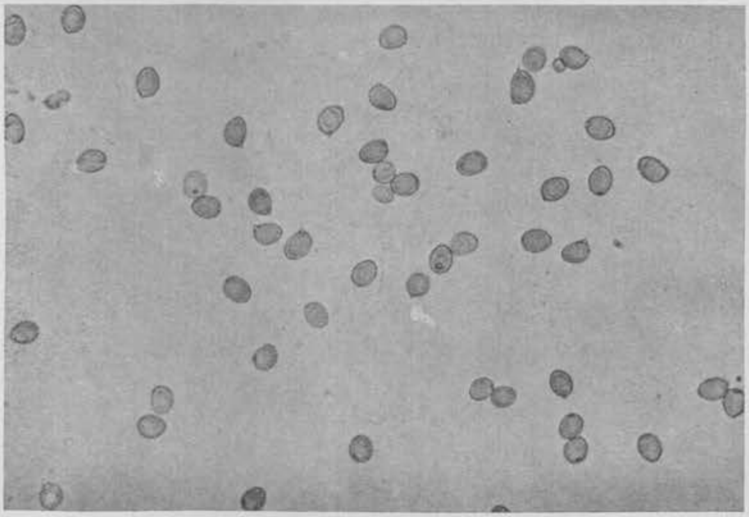


2

PLATE 1.



1



2

PLATE 2.

THE DISTRIBUTION OF BANANA WILT

By Otto A. Reinking

FIVE PLATES

INTRODUCTION

During the period 1925 to 1927, while the writer was making a study of the various banana varieties in the world, an opportunity presented itself to study the distribution of banana wilt (Panama disease) caused by *Fusarium cubense.* Former investigations relative to distribution indicated that the disease was world-wide, but authentic determination of the causal organism had not been made in all cases. The present studies were carefully checked with isolation and fungus determinations based on recent reports.(9, 11, 16) Up to the time of this investigation the disease had been recorded, outside of the Caribbean region, from Hawaii by Higgins,(7) Carpenter,(5) and Wilcox;(15) from the Philippines by Lee and Serrano;(8) from India by Basu,(1) Butler,(3) and Shaw;(12) from Australia by Tryon;(13) and from the Canary Islands and Africa by Dunlap through the Imperial Bureau of Mycology.(18, 19)

SCOPE OF PRESENT STUDIES

Investigations on banana wilt were made by the writer in the following countries: Philippine Islands, French Indo-China, Straits Settlements (Singapore and Penang), Federated Malay States, Siam, Dutch East Indies, Australia, Burma, and India. The disease was observed in all of these countries except French Indo-China. It is highly probable that it is present in the latter country, although it was not encountered during the survey. Special studies verified its presence in the localities given in Table 1.

DETAIL OF INVESTIGATIONS

A detailed account of the investigations, according to the countries where the disease was found, the varieties affected, and the studies made of it, is presented in the following discussion.

TABLE 1.—*Banana wilt (Panama disease); geographic distribution of diseased plants studied.*

Country.	Locality.	Date of observation.	Culture studies.
Philippine Islands	Los Baños, Laguna	Mar., 1925	*F. cubense* isolated.
Straits Settlements	Singapore	Oct., 1925	Do.
Do	Penang	Dec., 1925	No isolation.
Federated Malay States	Serdang	Dec., 1925	*F. cubense* isolated.
Do	Kuala Lumpur	Dec., 1925	No isolation.
Do	Kajang	Dec., 1925	Do.
Siam	Bangkok	Nov., 1925	*F. cubense* isolated.
Dutch East Indies	Buitenzorg, Java	Mar., 1926	No isolation.
Do	Pasar Minggoe, Java	Apr., 1926	*F. cubense* isolated.
Do	Tohoedan Experiment Station, Solo, Java.	Apr., 1926	No isolation.
Do	Pasoeroean, Java	Apr., 1926	Do.
Do	Banda, Molucca Islands	Aug., 1926	Do.
Australia	Brisbane (Pinkenba)	Oct., 1926	*F. cubense* isolated.
Burma	Hmawbi Experiment Gardens, near Rangoon.	Dec., 1926	No isolation.
India	Poona, Bombay Presidency	Jan., 1927	*F. cubense* isolated.
Do	Munsiganj, Dacca, Bengal	Jan., 1927	Do.
Do	Rampal, Dacca, Bengal	Jan., 1927	Do.

PHILIPPINE ISLANDS

The disease was first noted by Lee and Serrano(8) as being severe on the Latundan variety. Culture studies made by the writer also proved the disease to be due to *Fusarium cubense.*

BANANA VARIETY AFFECTED

1. Latundan

During March, 1925, studies of the disease situation were made by the writer. The Latundan variety was the only one observed to be affected. This banana is a common type with a world-wide distribution. In the West Indies a type of the variety is commonly known as the Apple or Manzana banana. In the Philippines this banana is most commonly planted for commercial purposes. The disease was observed only in the Manila region, indicating that it may have been introduced into the Islands. It was observed in its characteristic form in Calamba, Pansol, Lalakay, Los Baños, and Calauan, all in Laguna Province, Luzon. In some plantings 100 per cent infection was noted.

The characteristic wilting and yellowing of leaves along with severe splitting of the pseudostem characterized the disease (Plate 1, fig. 1). Interior symptoms, including the typically discolored vascular bundles, were present in each case. Culture studies showed that in all cases of disease typical *Fusarium cubense* was present in a pure state, thereby corroborating the finding of Lee and Serrano.

STRAITS SETTLEMENTS AND FEDERATED MALAY STATES

Up to the time of this investigation the banana-wilt disease had never been reported from these regions. Studies made from October to December, 1925, showed the disease to be present in the Straits Settlements on Singapore Island (10) and in the environs of Penang, and in the Federated Malay States at Kuala Lumpur, Serdang, and Kajang. It undoubtedly is widespread throughout the Federated Malay States wherever the susceptible varieties are planted. Recent studies made by Ward (14) apparently confirm these findings.

BANANA VARIETIES AFFECTED

1. Awak; Penang.
2. Embun; Singapore and Kajang.
3. Rastali; Penang, Kuala Lumpur, and Serdang.

The Embun variety is commonly and severely attacked (Plate 1, fig. 2; Plate 2, fig. 1). This banana is the common Gros Michel of commerce universally planted in the West Indies. Pisang rastali is similar to the Latundan variety of the Philippine Islands and the Apple or Manzana variety of the West Indies. The Awak variety is similar to the Nam Wa of Siam. It is commonly cultivated in Penang and in various parts of the Federated Malay States. External and internal symptoms of disease on all varieties were typical of the true banana wilt of the Caribbean region. Isolations made from specimens collected at Serdang and Singapore resulted in pure cultures of *Fusarium cubense*. In no cases of typical disease were other species of fusaria isolated.

SIAM

Banana wilt never had been reported as occurring in Siam. Observations made in November, 1925, showed the disease to be widespread and severe on one variety grown about Bangkok.

BANANA VARIETY AFFECTED

1. Nam Wa.

The Nam Wa variety is the commonest on the market and in the field. It is a starchy type that is usually cooked. The disease shows typical symptoms of wilting, but splitting of the pseudostem was not so common (Plate 2, fig. 2). Frequently plants appear to be partially resistant and trying to throw off the trouble. The disease was found on a trip into the Bang Sorn district and at the Bangkok Noi Experimental Orchard just out of Bangkok. Specimens were collected and taken to the Pasteur Institute for examination and culture studies. Microscopic examination showed the typical discolored vascular bundles and mycelium in the xylem tissue. Isolation from diseased portions produced pure cultures of *Fusarium cubense.*

DUTCH EAST INDIES

A special investigation of banana wilt was made in Java because of previous studies conducted by Gaumann(6) on a widespread vascular disease of bananas attributed to bacteria. Gaumann, in his study of this disease, failed to isolate *Fusarium cubense.* He isolated six other species of fusaria from old diseased material, but none of these produced disease in inoculation tests. At no time was one predominating fusarium found. Gaumann concludes that the vascular disease of the bananas in Java was caused by *Pseudomonas musæ* and that the genuine destructive Panama disease is similar but distinguished by the presence of *F. cubense* in the secondary vascular bundles.

In the recent study of the vascular diseases of banana in Java made by the writer the typical banana wilt (Panama disease) caused by *Fusarium cubense* was observed. External and internal symptoms were typical of those described by Brandes(2) in the West Indies. *Fusarium cubense* was isolated in pure culture from all typical cases of disease. Many banana varieties were found to be susceptible to disease, while on the other hand many resistant varieties exist.

BANANA VARIETIES AFFECTED

Pasar Minggoe, Java. Ragoenan Agricultural Experimental Station (near Batavia).

1. Ambon bodas.
2. Ambon poetih (Gros Michel) (Plate 3, fig. 1).
3. Besi.
4. Boeboejan.
5. Kepok koening.
6. Kloetoek soekoen.
7. Kool.
8. Mentek.
9. Poelo alar.
10. Radja.
11. Radja djawa.
12. Radja koesta.
13. Radja pakoewon (Plate 3, fig. 4).
14. Radja pelilit.
15. Radja pretel.
16. Radja sereh bodas (Latundan, Philippines).
17. Radja sijem (Nam Wa, Siam).
18. Sembot.
19. Silo Kapoek.
20. Soesoe (Plate 3, fig. 3).
21. Songgroito (Sri) (Plate 3, fig. 2).
22. Sribali (Gros Michel type).
23. Tjandi.
24. Tjeleket.
25. Tjoemet.

Buitenzorg, Java. Tjipakoe Experiment Station.

1. Radja.

Solo, Java. Tohoedan Experimental Station.

1. Galigis.
2. Kapas idjo.
3. Kepok ambon.
4. Panggra.
5. Sobo kepok.
6. Sobo madoera.
7. Soesoe.
8. Soesoe bodas (Latundan, Philippines).

Pasoeroean, Java. Pasoeroean Experimental Station.

1. Gading.
2. Gembang.
3. Kapas idjo.
4. Panggra.
5. Radja djawa.

Moluccas. Banda Islands (Banda Neira and Poeloe Ay).

1. Radja (Ambon poetih) (Gros Michel).
2. Soesoe (Latundan, Philippines).

Possibly some of the local variety names in the above list refer to the same banana. It was impossible to check each definitely because of lack of fruit. The same banana names used in different localities of Java cannot always be taken as referring to one distinct variety, because the same banana variety receives different names depending on the locality from which it has been collected. The Gros Michel banana of the West Indies is called Ambon poetih in various parts of Java and Radja in Amboina and the Banda Islands. The Radja variety in Java is therefore totally different from the Radja of Ambon. The name Soesoe as used in Java may refer to two different varieties of banana. In one locality the common Apple banana of the West Indies is called Radja sereh bodas, in another locality it is called Soesoe or Soesoe bodas. The name Soesoe is also given to an entirely different banana similar to the real Soesoe in the Federated Malay States. These few cases are cited to make it clear that local names, as often given to bananas in the Dutch East Indies, may be very misleading. The names given in the list above have been taken directly from the experimental station records cited or from the local names according to the place listed. Consequently a duplication of actual varieties may exist in the list, as fruit was not always present for differentiation purposes.

A careful study made in March, 1926, for disease in the banana collection at the Ragoenan Experimental Station, situated at Pasar Minggoe, Java, showed the disease to be spread throughout the entire collection. According to the list given above, twenty-five varieties among some one hundred fifty types were found to have the disease. During the following month a survey of the collection at the Tohoedan Experimental Station at Solo showed eight varieties affected, and at the Pasoeroean Experimental Station at Pasoeroean in eastern Java, five varieties were affected. The banana wilt is evidently widely spread throughout the Dutch East Indies, as typical cases of diseases were found on Banda Neira and Poeloe Ay of the Banda Islands in the Molucca group.

SEVERITY OF DISEASE IN JAVA

The banana wilt in Java, as well as generally throughout the Far East, is usually not much in evidence in the small native plantings, because some five to twenty varieties of bananas are commonly planted in the same plot. Most, or a great part, of these varieties are resistant, and one occasional sick plant of a susceptible variety causes little anxiety and is often not recognized as suffering from an infectious trouble. The Ambon poetih (Gros Michel) is possibly the most susceptible of all varieties. It is seldom extensively planted by the natives as they prefer other kinds for their own use. Only when this variety is extensively planted, as is done near a special market, does the disease become really noticeable. Solid plantings of Ambon poetih on diseased soil may show severe disease within six months and may have as high as 90 per cent disease after twelve months of growth. The following diagram illustrates severe infection of Gros Michel in small, solid plantings made at the Ragoenan Agricultural Experimental Station at Pasar Minggoe, Java. The O's and and X's designate the various plants according to the planting plan. X's indicate locations of diseased plants with external symptoms.

Banana wilt in 11.5-month-old planting at Pasar Minggoe, Java.

[O=healthy plant; X=diseased plant.]

Variety, Ambon Poetih.	*Variety, Sribali.*
X X O O X O O	O X X O X O X
X X X X X X X	O O X O X O X
X X X X O X X	O X X O X X
X O O O O X X	O X X O X O
Total plants, 28.	Total plants, 26.
Diseased plants, 19.	Diseased plants, 14.
Diseased, 68 per cent.	Diseased, 54 per cent.

The variety Ambon poetih is the Gros Michel of the West Indies. Sribali was reported as being a type of Ambon poetih. The plants listed above were planted April 15, 1925. March 4, 1926, eleven and one-half months after planting, the Ambon poetih variety had 68 per cent disease (Plate 3, fig. 1; Plate 5, fig. 1) and both varieties were 100 per cent diseased. The plants were small as they were growing on rather heavy soil. The photographs clearly show the external symptoms of disease identical to that of the banana wilt in the West Indies.

Examination made in March, 1926, of other small plantings of single varieties showed severe infection in some cases. A list of these varieties with percentage of infection is given below:

Banana wilt in plantings at Pasar Minggoe, Java.

	Infection. Per cent.
Radja sereh	40
Radja sereh bodas, 9 diseased among 98 plants	9
Radja sijem	90
Soesoe, 2 diseases among 64 plants (Plate 4, fig. 2)	3
Songgroito (Sri) (Plate 3, fig. 2)	10

Radja sereh is similar to the Latundan of the Philippines and the Apple or Manzana variety of the West Indies. Radja sereh bodas is a type of Radja sereh. Radja sijem is similar to the Nam Wa of Siam. These two varieties are commonly found diseased wherever grown. The disease is generally associated with definite varieties grown under different conditions in various parts of the world. The Soesoe variety is the Federated Malay States type. Songgroito (Sri) is a Dutch East Indies type that is frequently subject to disease.

Isolations were made of the first cases of disease observed. The external, internal, and microscopic aspects of the cases studied were identical with the real banana wilt (Panama disease) of the West Indies. Four typical cases of disease were selected for isolations as follows:

Variety.	Collected.	Locality.
Radja	Feb. 13, 1926	Buitenzorg (Tjipakoe), Java.
Ambon poetih	Feb. 13, 1926	Pasar Minggoe, Java.
Do	Feb. 13, 1926	Do.
Songgroito (Sri)	Feb. 13, 1926	Do.

In each case a pure culture of *Fusarium cubense* was isolated. No other fusaria were present in the diseased tissues. Determinations of *Fusarium cubense* were made from cultural characters and spore measurements of the fungus growing upon potato agar and rice. The typical aromatic odor of the organism when grown on rice was produced.

SPECIAL ISOLATION STUDIES

In order to prove definitely that *Fusarium cubense* is associated with all the varieties of bananas subject to the disease, sixteen varieties found diseased were collected March 25, 1926, at the Ragoenan Experimental Station, Pasar Minggoe, and taken to Buitenzorg for isolation and culture studies. The writer is indebted to Dr. Van Hall and members of the Institute voor Plantenziekten at Buitenzorg for use of laboratory and equipment. Each variety collected had typical symptoms of the disease. A list of the varieties from which isolations were made follows:

Isolations of pure cultures of F. cubense, Pasar Minggoe banana collection, March, 1926.

Variety.	Place of isolation.
1. Ambon bodas	Pseudostem.
2. Besi	Do.
3. Kloetoek soekoen	Do.
4. Kool	Do.
5. Mentek	Do.
6. Radja (batoel)	Do.
7. Radja koesta	Do.
8. Radja pakoewon	Do.
9. Radja pelilit	Do.
10. Radja pelilit	Rhizome.
11. Radja pretel	Pseudostem.
12. Radja sereh bodas	Do.
13. Radja sijem	Do.
14. Sembot	Do.
15. Soesoe (Banjoewangi type)	Do.
16. Tjeleket	Do.

The Besi and Sembot varieties had only mild cases of infection. Isolations were made March 26 on acidified potato-agar plate cultures by taking small pieces of infected pseudostem and plating them out. In one case, that of Radja pelilit, isolations were made from the infected vascular bundles of the rhizome. The portion of the diseased pseudostem of variety Tjeleket was taken near the top of the plant just below the leaf blades. In all other cases portions of the pseudostem, approximately one foot above the ground, were taken. Microscopic examinations of diseased bundles showed in all cases the presence of mycelium in the xylem tubes.

March 29 examination of the plates showed that in each case a pure culture of fusarium grew from the diseased portions. The fusaria produced from each were so striking and pure that there was no question about the presence of one single strain in all varieties. The growth from infected portions of the rhizome of the Radja pelilit was identical with that from the pseudostem.

Transfers of the fungus developed from each variety were made to tubes of potato agar, rice, and stems of *Tephrosia candida,* for final identification of the organism. Subsequent examination of these cultures proved that the organism in every case was a pure culture of *Fusarium cubense* identical in every respect, physiologically and morphologically, with the organism as described from Central America and the West Indies.(11)

The isolations made from typical cases of banana wilt (Panama disease) from this region of Java proved that *Fusarium cubense* was present in a pure state in every variety from which isolations were made. In no case was any other type of fusarium isolated. There is no reason to believe that the disease in Java is in any way different from the disease in other parts of the world.

AUSTRALIA

Banana wilt undoubtedly has been present in Australia for many years. Tryon(13) in 1912 mentioned a disease investigated by Dr. Joseph Bancroft in 1874–1876 attacking the sugar banana in southern Queensland. The disease was also reported as occurring in the common plantain growing in that region. Tyron described the disease and stated that it was similar to the Panama disease. The description of the disease leaves no doubt that the trouble was identical with the banana wilt (Panama disease). This is especially true in view of the present findings.

The following banana varieties have been reported to be affected.

BANANA VARIETIES AFFECTED

1. Lady Finger.
2. Sugar banana.
3. Gros Michel.
4. Plantain (variety name not mentioned).

The writer made observation and isolation studies of the disease only on the Lady Finger variety. The disease was reported to me by Australian investigators as occurring on the other named varieties. The Lady Finger banana is commonly grown in Australia. It should not be confused with the type designated as Lady Finger in the Caribbean region. The Australian Lady Finger banana is similar to the Rio banana of Tahiti and the Brazilian banana of Hawaii.

The disease was studied in a plantation at Pinkenba, down the river from Brisbane. It was severe on the Lady Finger variety and showed typical symptoms with split pseudostems and wilted, yellow leaves. Diseased specimens of the rhizome and pseudostem were taken to Brisbane for microscopic examination and isolation studies. The writer is indebted to Prof. E. J. Goddard, of Queensland University, for the use of laboratories and equipment. Internal symptoms were typical of the true banana wilt except that more yellowed strands predominated and more rotted areas were present throughout the infected pseudostem. Certain varieties of bananas affected with the fusarial wilt may show a preponderance of yellowed vascular bundles over the reddish or black. Pure cultures of *Fusarium cubense* were isolated from the rhizome and pseudostem. The fungus was isolated both from reddish black and yellow stages of discoloration in bundles.

BURMA

The banana wilt disease was observed in southern Burma near Rangoon at the Hmawbi Agricultural Experimental Station. The disease was not seen in the northern Mandalay region or in central Burma. Only one variety of banana was found to be attacked.

BANANA VARIETY AFFECTED

1. Kala.

The Kala variety is similar to the Latundan of the Philippines and the common Apple or Manzana banana of the West Indies. This variety and the Gros Michel are the two most commonly attacked in all parts of the world where grown. All characteristic symptoms including splitting were observed on diseased plants. Microscopic examination showed discolored vascular bundles with fungus mycelium in the xylem tubes. No isolations were made.

INDIA

Basu(1) in 1912 reported the presence of a banana disease in Chinsurah. Certain varieties were said to have been killed out entirely. A description of the disease leaves no doubt that the trouble was identical with the banana wilt (Panama disease). This is especially true in view of the present findings. In 1914 Shaw(12) and in 1915 Butler(3) again reported the presence of the disease.

The present investigation covered the Dacca District, Bengal, in eastern India, and the Poona District, Bombay, in western India. In the Dacca region it was severe, especially in garden plantings that had been cultivated for years about the farm houses. The disease was observed in the Munsiganj and Rampal areas of the Dacca region. At Poona the disease was observed only on a seedling variety found growing at the Ganeshkhind Botanical Gardens.

BANANA VARIETIES AFFECTED

1. Kabari; Dacca District, Bengal.
2. Sonkel Chanda (from seed); Poona District, Bombay.

The Kabari variety is similar to the Nam Wa of Siam and Awak of the Federated Malay States. It is commonly cultivated in the Far East. Sonkel Chanda is a seedling variety grown from the seed of the common Sonkel variety of India. Typical external symptoms of wilting and splitting were present in each case. Microscopic examination showed the presence of mycelium in the xylem tubes. Pure cultures of *Fusarium cubense* were isolated from each case of disease.

DISCUSSION

The foregoing studies on banana wilt (Panama disease) clearly show that this disease is generally widespread in most banana sections of the world. The disease is generally associated with definite varieties wherever grown and affects these varieties most severely. Gros Michel apparently is the most susceptible. The Apple Manzana variety as known in the West Indies is generally found to be diseased to a greater or lesser degree. The Awak variety of Penang or Nam Wa of Siam is commonly diseased where grown throughout the Far East. The following table gives the local variety names in the various countries where these diseased varieties were observed:

Banana varieties most commonly found diseased.

Gros Michel; West Indies and Central America. Also known as—
  Embun; Federated Malay States.
  Ambon poetih; Java.
Manzana or Apple; West Indies and Central America. Also known as—
  Latundan; Philippine Islands.
  Rastali; Federated Malay States and India.
  Kala; Burma.
  Radja sereh; Java.
Awak; Penang, Straits Settlements. Also known as—
  Nam Wa; Siam.
  Radja sijem; Java.
  Kabari; India.

Fusarium cubense was isolated from all typical cases of disease studied. No other fusarium was found in typical diseased lesions. Brandes(2) clearly proved that typical disease can be produced by inoculation with *Fusarium cubense*. Later studies by Carleton(4) and Reinking(9) also show this to be true. External and internal symptoms were identical in all cases of disease observed on the various varieties as grown in all countries visited. The universal presence of *Fusarium cubense* in typical cases of banana wilt throughout the areas covered in this study, considered with the successful inoculation studies previously made and the similarity of external and internal symptoms, seem to be evidence enough that the disease is everywhere identical.

SUMMARY

Symptomatic and isolation studies clearly show that the banana wilt (Panama disease) is identical in the following countries: Philippine Islands, Straits Settlements (Singapore, Penang), Federated Malay States, Siam, Dutch East Indies, Austrialia, Burma, and India.

The banana wilt (Panama disease) is world-wide in its distribution, being found in practically all banana regions.

Certain varieties of bananas are highly susceptible to the disease wherever grown.

The Gros Michel is subject to the disease in most parts of the world where it is grown.

Studies conducted in Java show the presence of *Fusarium cubense* in all typical cases of infection. No other fusaria were found associated with typical cases of the disease.

There is no reason to believe that the disease in Java is in any way different from the disease in other parts of the world.

The universal presence of *Fusarium cubense* in typical cases of banana wilt (Panama disease) throughout the areas covered in this study, considered along with the successful inoculation studies previously made and the similarity of external and internal symptoms, seem to be evidence enough that the disease is everywhere identical.

LITERATURE CITED

1. BASU, S. K. Report on the banana disease of Chinsurah. Quart. Journ. Dept. Agr. Bengal 4 (1911) 196–198.
2. BRANDES, E. W. Banana wilt. Phytopath. 9 (1919) 339–389.
3. BUTLER, E. J. Plant Pathology. Ann. Rpt. Bd. Sci. Advice India 1915–16 (1917) 103–109.
4. CARLETON, M. A. Note on the fusarium wilt disease of bananas. Science 56 (1922) 663–664.
5. CARPENTER, C. W. Banana diseases. Hawaii Agr. Exp. Sta. Rpt. 1917 (1918) 40–42.
6. GAUMANN, E. Over een bacterieele vaatbundelziekte der Bananen in Nederlandsch-Indie. Meded. Inst. voor Plantenziekten 48 (1921) 1–135.
7. HIGGINS, J. W. The Banana in Hawaii. Hawaii Agr. Exp. Sta. Bull. 7 (1904).
8. LEE, H. A., and F. B. SERRANO. Banana wilt in the Philippines. Phytopath. 10 (1920) 504–505.
9. REINKING, O. A. Fusaria inoculation experiments. Relationship of various species of Fusaria to wilt and Colorado disease of banana. Phytopath. 16 (1926) 371–392.
10. REINKING, O. A. Banana wilt disease on the Island of Singapore. Phytopath. 16 (1926) 369–370.
11. REINKING, O. A. Tropical Fusaria. Philip. Journ. Sci. 32 (1927) 103–253.
12. SHAW, J. F. Mycology. Ann. Rpt. Bd. Sci. Advice India 1914 15 (1916) 104–109.
13. TRYON, HENRY. The banana in Queensland. Diseases of the banana. Queensland Agr. Journ. 28 (1912) 116–119.
14. WARD, F. S. Preliminary report on Fusarium cubense causing Panama disease in Malaya. Malayan Agr. Journ. 16 (1928) 76–87.
15. WILCOX, E. V. Summary of investigations. Hawaii Agr. Exp. Sta. Rpt. 1914 (1915) 7–24.
16. WOLLENWEBER, H. W., C. D. SHERBAKOFF, O. A. REINKING, HELEN JOHANN, and ALICE A. BAILEY. Fundamentals for taxonomic studies of Fusarium. Journ. Agr. Res. 30 (1925) 833–843.

17. WOLLENWEBER, H. W., and O. A. REINKING. Aliquot Fusaria Tropicalia nova vel revisa. Phytopath. 15 (1925) 155–169.
18. WOLLENWEBER, H. W., and O. A. REINKING. Mycological notes. Panama disease of bananas in the Canaries and West Indies. Trop. Agriculture 3 (1926) 8.
19. WOLLENWEBER, H. W., and O. A. REINKING. Mycology. Ann. Rpt. Lands and Forests Dept. Sierra Leone for the year 1924 (1926) 17–19.

ILLUSTRATIONS

PLATE 1. BANANA WILT IN THE PHILIPPINE ISLANDS AND SINGAPORE

FIG. 1. Banana wilt in Latundan variety; splitting of pseudostem. Lalakay, Los Baños, Laguna, Philippine Islands; March 31, 1925.

2. Banana wilt of Pisang embun; longitudinal section through rhizome and portion of pseudostem, showing discolored vascular bundles. Adam Road, Singapore, Straits Settlements; October 20, 1925.

PLATE 2. BANANA WILT IN SINGAPORE AND SIAM

FIG. 1. Banana wilt of Pisang embun; note drooping of outer, older leaves and upright, yellowed central leaf. Adam Road, Singapore; October 20, 1925.

2. Banana wilt of Klui Nam Wa. Bangkok Noi Experimental Orchards near Bangkok, Siam; November 8, 1925.

PLATE 3. BANANA WILT IN JAVA, DUTCH EAST INDIES

FIG. 1. Severe case of banana wilt of Pisang ambon poetih (Gros Michel). Pasar Minggoe Experimental Station, Java; March 6, 1926.

2. Banana wilt in planting of Pisang Songgroito (Sri); 10 per cent of plants diseased; apparently healthy plant of same age in background. Pasar Minggoe Experimental Station, Java; March 6, 1926.

PLATE 4. BANANA WILT IN JAVA, DUTCH EAST INDIES

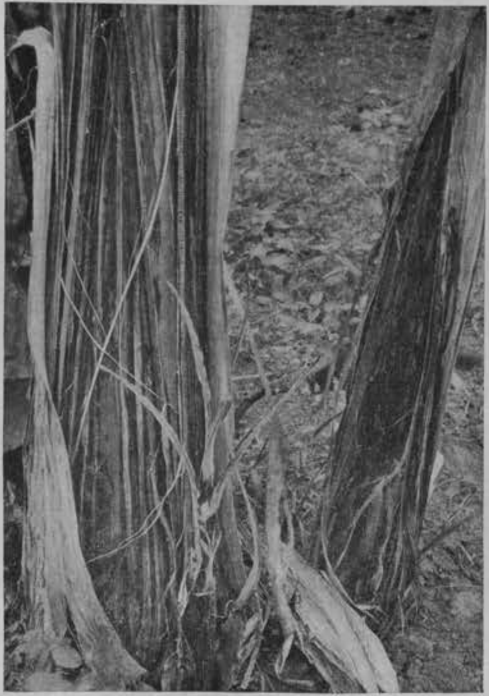
FIG. 1. Banana wilt in planting of Pisang soesoe; 3 per cent of plants diseased. Pasar Minggoe Experimental Station, Java; March 6, 1926.

2. Banana wilt of Pisang radja pakoewon. Pasar Minggoe Experimental Station, Java; March 6, 1926.

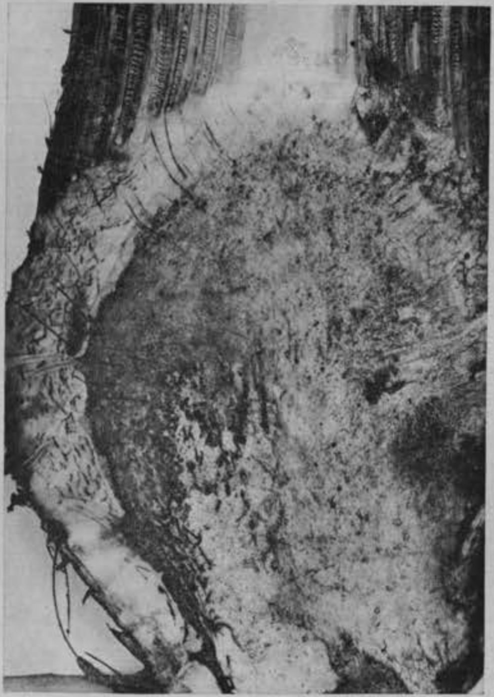
PLATE 5. BANANA WILT IN JAVA, DUTCH EAST INDIES

FIG. 1. Banana wilt in planting of Pisang ambon poetih (Gros Michel); 68 per cent of plants badly diseased according to external symptoms; note stunted growth and splitting of pseudostems. Pasar Minggoe Experimental Station, Java; March 6, 1926.

2. Banana wilt in planting of Pisang sribali (Gros Michel type). Sribali is a type of Ambon poetih; 54 per cent of plants badly diseased according to external symptoms; note stunted growth. Pasar Minggoe Experimental Station, Java; March 6, 1926.

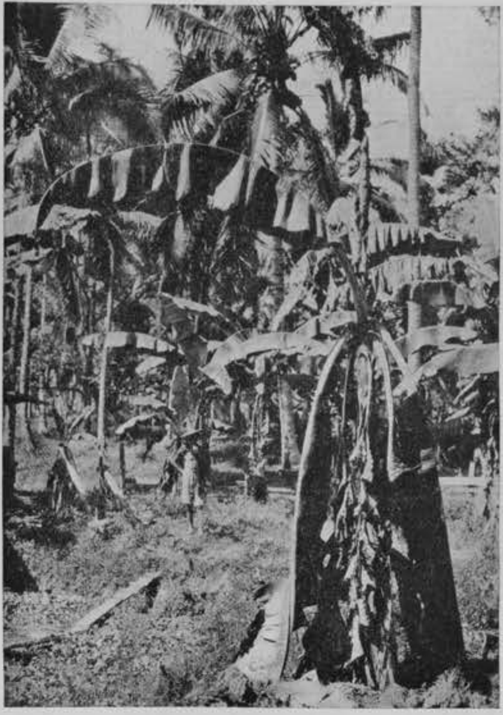


1

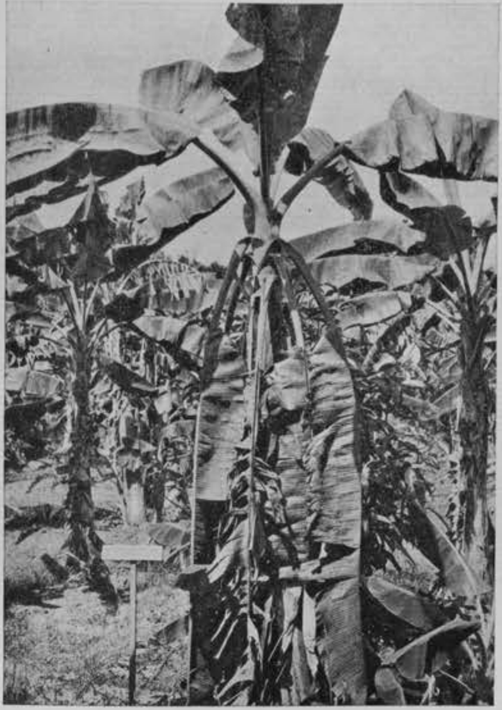


2

PLATE 1.

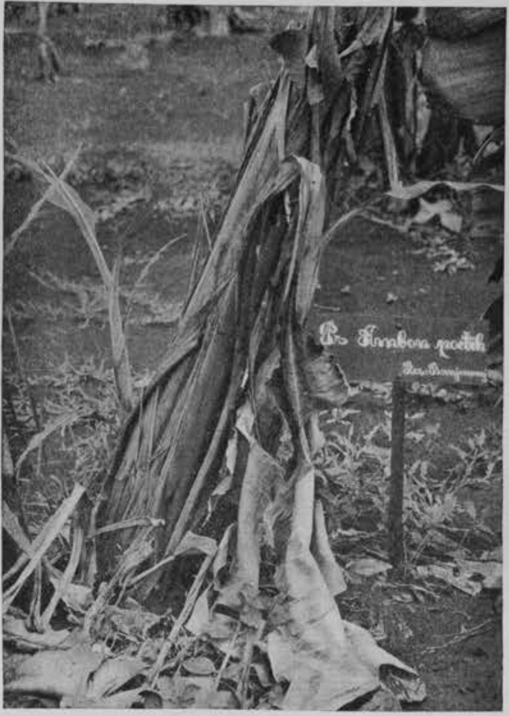


1

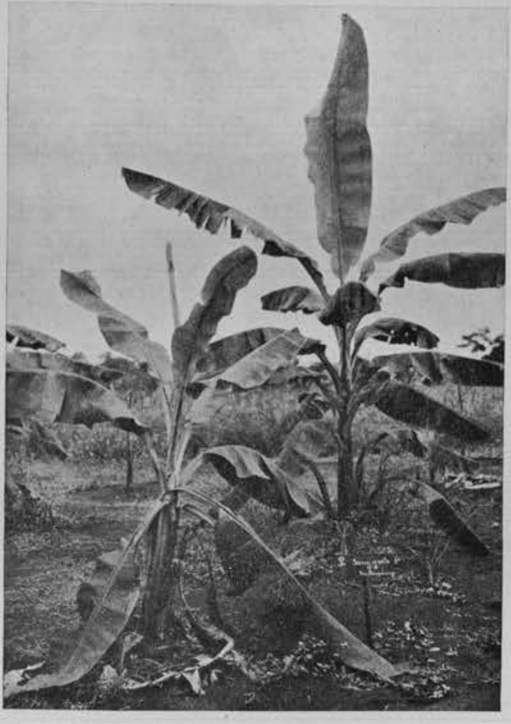


2

PLATE 2.

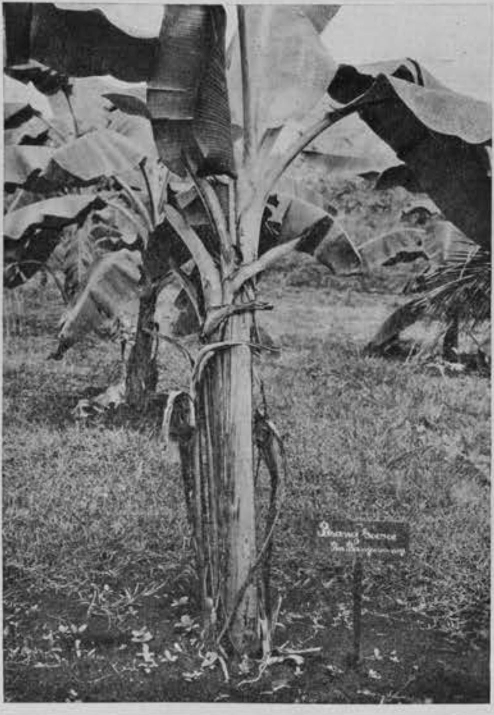


1

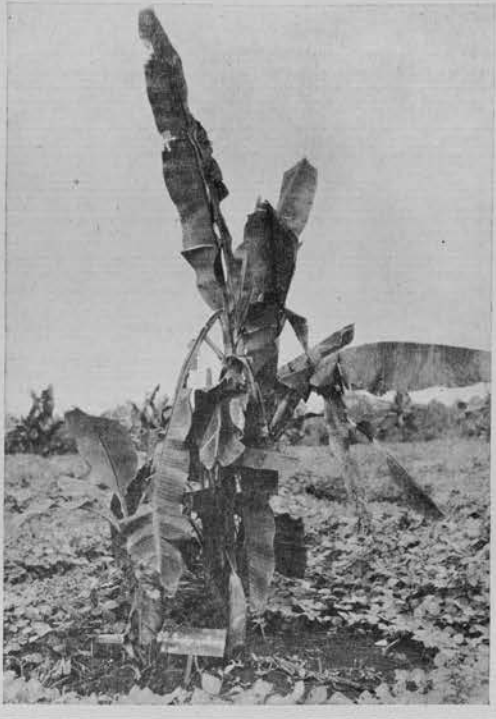


2

PLATE 3.

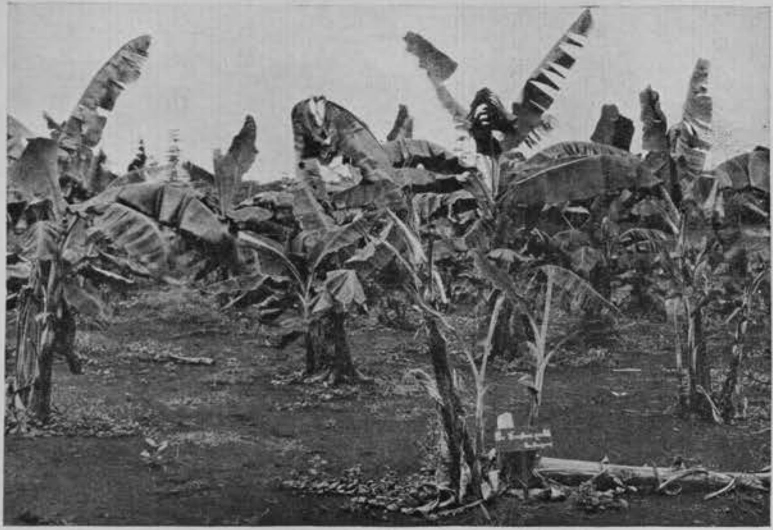


1

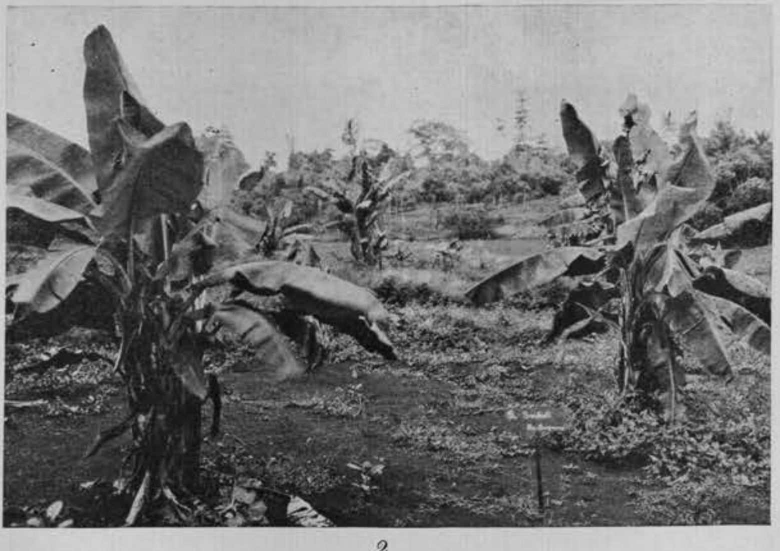


2

PLATE 4.



1



2

PLATE 5.

CULTIVATION OF AVIAN-PEST VIRUS (NEWCASTLE DISEASE) IN TISSUE CULTURE

By TEODULO TOPACIO[1]

Of the Veterinary Research Division, Bureau of Animal Industry, Manila

The development by Burrows, Carrel, and the Lewises of various methods for cultivating different kinds of tissues in vitro was followed by the application of the technic in the propagation of several viruses affecting man and animals. Levaditi(8) kept rabies virus viable in growing cells of rabbit testicles in monkey plasma for a period of one month. In the same year Steinhardt, Israeli, and Lambert(12) cultivated the agent of vaccinia in rabbit cornea and plasma for more than thirty days. Parker and Nye(9) estimated that their cultures of this virus in rabbit testicular tissue had multiplied 51,000 times after eleven passages. Carrel and Rivers(1) also cultivated vaccinia, using chick-embryo skin, cornea, and brain, and calculated that the virus increased 10,000 to 100,000 units per cubic centimeter after eight passages. Dochez, Mills, and Kneeland(2) cultivated the virus of common cold in chick-embryo pulp for fifteen generations. Pinkerton and Haas(10) studied the virus of typhus fever in cultures of guinea-pig tissue and scrotal exudate. Foot-and-mouth disease was cultivated by Hecke(6) on the skin of guinea-pig embryos for eleven generations (forty-nine days) and in another series the virus survived for forty-six days. In both cases the virus became avirulent on further passage. In 1932 the same author(7) cultivated the virus of hog cholera.

It will be noted that the majority of the viruses thus far cultivated were diseases of man with the exception of rabies, foot-and-mouth disease, and hog cholera. More recently the virus of fowl plague was added to the list. Hallauer(5) succeeded in propagating this agent in different tissues of the chicken embryo. Single tissue or the entire embryo pulp was satisfactory for growing the virus according to this author. The following year

---

[1] Bureau of Animal Industry Technical Bulletin 5. From the veterinary research division, Bureau of Animal Industry, Manila. Received for publication January 12, 1933.

Plotz(11) at the Pasteur Institute also succeeded in cultivating fowl plague in fifteen passages on chicken-embryo pulp covering a period of ninety-four days.

Concerning Newcastle disease or avian-pest virus the writer failed to find any report in literature dealing with its cultivation in vitro. In the present paper the successful cultivation of this agent will be described.

MATERIALS

In this work three strains of virus have been used; namely, laboratory strain, Farinas strain, and Stotsenburg strain. Best results were obtained with the laboratory strain which was kept in continuous passage for about five years.

Preparation of the virus.—The spleen of a bird artificially infected was removed aseptically at the height of the disease (four or six days after inoculation). It was ground in a sterile mortar and then suspended in 4 cc of Tyrode solution pH 8.4. The mixture was allowed to extract for one or two hours in a Frigidaire and then centrifuged at low speed for one minute to cause the tissue fragments to settle. The supernatant material served as stock virus for the initial culture. The subculture virus was prepared from one or more Carrel flask cultures suspended in 1 to 2 cc of Tyrode solution as described for the initial virus material.

Plasma.—Plasma of heparinized blood from healthy susceptible birds was collected aseptically. A 1 : 1000 heparin-saline solution was added to the heart blood in the proportion of 1 cc of heparin to 10 cc of blood to prevent coagulation. After centrifugation the clear plasma was stored on crushed ice in the refrigerator until wanted for use.

Embryo tissue.—Chick embryos 8 to 10 days old were utilized in the preparation of the tissue medium. Each embryo was minced fine with scissors in a Petri dish, and the fragments were washed in Tyrode solution before exposure to the virus suspension.

Test birds.—White Leghorns of known susceptibility were employed as virus producers and test birds.

Tyrode solution.—The following formula was adopted: NaCl, 8 g; KCl, 0.2 g; $CaCl_2$, 0.2 g; $MgCl_2$, 0.1 g; $NaHPO_4$, 0.05 g; $NaHCO_3$, 1 g; glucose, 1 g; distilled water, 1,000 cc. After filtration through a Seitz filter the solution was tested for sterility before use.

TECHNIC

Plasma diluted with Tyrode solution in the proportion of 1 part plasma and 1 to 2 parts Tyrode was distributed in sterile Carrel D-flasks in 2.5-cc amounts. One cubic centimeter of virus suspension was added to each minced whole embryo tissue and the mixture was stirred thoroughly and allowed to stand for one-half hour. With a broad-tip pipette, the tissue-virus mixture was distributed in each Carrel D-flask in 0.5-cc amounts.[2] The flasks were then shaken gently from side to side to disperse the tissue particles equally in the medium, which became firm in a few minutes. Cotton plugs and rubber caps were used as stoppers. The cultures were incubated at 37° C., and transfers were made every three or five days. The final dilution of the virus in initial cultures was approximately 1 : 30.

ADAPTABILITY OF THREE STRAINS OF VIRUS TO CULTIVATION

To determine which strain was most suitable for cultivation, initial cultures of each strain were made and tested separately.

Laboratory strain.—Of the initial cultures made with this strain the average survival period was six to fourteen days. A test bird injected with the 14-day-old culture developed typical symptoms without profuse diarrhœa, but complete recovery followed. One culture 6 days old when injected into a susceptible bird killed the fowl. Another 6-day-old culture produced marked symptoms in another bird but it recovered. The birds that recovered were later found immune against a test dose of a 1: 10 dilution of virulent saliva injected in the breast muscle.

Farinas strain.—Four-day-old initial cultures of this strain produced mild but atypical symptoms of avian pest in the inoculated birds, which later resisted a test inoculation of virulent saliva.

Stotsenburg strain.—Six-day-old initial cultures of this strain when injected into susceptible birds failed to infect. The birds succumbed to regular test dose of 1 cc of a 1: 10 dilution of virulent saliva.

In the viability test of the cultures, the entire contents of one or two Carrel flasks were emulsified in a little Tyrode solution and injected in the breast muscle of the test bird. The birds that survived were injected with a virulent test dose of infected saliva fourteen days after apparent recovery.

---

[2] Five-tenths cc tissue-virus mixture contains 0.1 cc virus suspension and 0.4 cc tissue.

CULTIVATION OF THE LABORATORY STRAIN IN TISSUE CULTURE

The result of the adaptability tests just described gave evidence that the laboratory strain was the most suitable for cultivation. The first initial culture was prepared February 15, 1933, according to the technic already outlined. Up to and including the thirty-first subculture, June 9, 1933, the virus remained infective, representing a total viability period of one hundred twelve days.

Every viable subculture in the entire series of thirty-one subplants was diluted from 1 to 30 times, approximately. There was, therefore, no doubt that the virus had multiplied regularly in the medium employed in thirty-one successive subplants. Farinas(3) determined the minimal infective dose of virulent saliva as 1 cc of a dilution of 1 : 1,250. In my own tests I succeeded in infecting a bird with 1 cc of a dilution of 1 : 25,000 virulent blood from a natural case. The thirty-first subplant killed a test bird within the regular period of five days after the inoculation of the standard test dose used in the beginning of the series. This is clear evidence that multiplication of the virus had taken place.

The intervals between testing periods for viability of subplants varied from every subplant in the first ten transfers to every five or more subplants thereafter in order to reduce the waste in the use of birds to the minimum. In all seventeen test birds were used, of which thirteen died and four developed symptoms but recovered. Those that recovered were found immune to a test dose of 1 cc of a 1 : 10 dilution of virulent saliva from infected birds. Five cubic centimeters of culture virus in saline comprised the dose given intramuscularly through the viability tests of the subcultures.

In some instances the cultures became contaminated, but by filtering a Tyrode suspension of these through a Seitz filter or Berkefeld N or W candles, the virus was freed from contamination without difficulty and no interruption occurred throughout the entire series up to and including the thirty-first subculture. This filterability of the culture virus through such filters of dense porosity seems to indicate that the virus particles have approximately the same size as the particles of foot-and-mouth disease virus or possibly are smaller. At any rate a certain amount of contamination did not seem to interfere with the viability and multiplication of the active agent. The filtrates containing the virus were used to inoculate the subcultures immediately following the contaminated ones and the chain was kept intact until further transfers were discontinued. Table 1 records the thirty-one subplants in the entire series including the viability tests.

TABLE 1.—*Viability tests on avian-pest virus (laboratory strain) cultivated in normal chicken plasma and embryo pulp at 37° C.*

Date.	Bird No.	Initial culture.	Subplant.	Age of virus when tested.	Amount injected.	Result.
				Days.	*cc.*	
Feb. 15	1	No. 1		7	5	Died.
Feb. 18			First	7		
Feb. 21	2		Second	11	5	Do.
Feb. 25	3		Third	14	5	Do.
Feb. 28	4		Fourth	17	5	Do.
Mar. 3	5		Fifth	22	5	Slight symptoms; recovered.[c]
Mar. 7	6		Sixth	27	5	Died.
Mar. 11	7		Seventh	29	5	Do.
Mar. 16	8		Eighth	33	5	Do.
Mar. 20	9		Ninth [a]	37	[b] 10	Do.
Mar. 23	10		Tenth	40	5	Do.
Mar. 26	11		Eleventh	43	5	Clinical symptoms; recovered.[c]
Apr. 7	12		Fifteenth	54	5	Very ill; killed.
Apr. 25	13		Twentieth	72	5	Slight symptoms; recovered.[c]
May 2	14		Twenty-second.	77	5	Died.
May 14	15		Twenty-fifth.	90	5	Do.
June 5	16		Thirtieth [a]	107	5	Slight symptoms; recovered.[c]
June 9	17		Thirty-first	112	5	Died.

[a] Cultures became contaminated but after filtration contamination was removed and subplants were resumed.

[b] Filtrate.

[c] Immune to test inoculation with virulent saliva.

TISSUE PREDILECTION

Tissue predilection of the virus under cultivation was not observed during the work since the virus when grown in separate cultures of skin, visceral organs, and brain, showed no apparent peculiar behavior. Such cultures were as viable as those grown in a medium of whole embryo pulp.

One interesting observation with regard to the filtered virus was the fact that whenever it was used as inoculum the initial culture had a noticeably lower virus content, as shown by the mild symptoms produced and the prompt recovery of injected susceptible birds. On subsequent subcultures, however, the same dose of culture injected into a susceptible fowl was invariably fatal. Evidently the original concentration of the virus was regained by multiplication after a number of passages, since in every transfer the virus had suffered increasing dilutions at the rate already stated.

IMMUNITY IN CULTURE VIRUS

There is reason to suspect that a subinfectious dose of culture virus might produce immunity without eliciting marked symptoms in the inoculated bird. Test birds inoculated with culture virus from the 5th, 11th, 13th, and 16th subplants, for example, showed slight evidence of infection followed by recovery, yet they resisted a retest with virulent saliva fourteen days afterwards. The birds were immune. In order to establish this phase of immunity on a permanent basis, further work would be necessary. It appears, therefore, that the immunity induced by cultured virus did not differ from that which followed an attack of natural infection.

CULTURED VIRUS VACCINE

Preliminary work on this subject has been started. While the result in a few trials appeared promising, further experiments on this point are in progress in order that a definite conclusion can be drawn.

HISTOPATHOLOGICAL OBSERVATIONS ON SLIDE CULTURES

Fragments of spleen, liver, and brain from infected birds were grown in hanging drops of normal chicken plasma at 37° C. In the same manner normal embryo organs (skin, liver, intestines, etc.) infected in vitro were cultured in plasma drops. In a number of trials the growing tissues five days old were examined microscopically under high and low magnifications, but no abnormal intracellular changes of great significance were noted. In preparations fixed in Schaudinn's solution and stained with eosin hæmatoxylin, the nuclei of the epithelial cells appeared pyknotic. Similar intranuclear changes were observed by Fukushima, Shimomura, and Oyama(4) in the cells of sections from visceral parenchymatous organs removed from birds that had died of the disease. Of course, it is quite possible that we have not yet hit upon the staining method that would bring into view the changes that the ordinary technic failed to demonstrate. Likewise, these authors failed to note any cellular inclusions in the course of their studies.

DISCUSSION

During the selection of a suitable strain of virus for purposes of cultivation it was shown that a certain strain was more adaptable than others. In the present work the laboratory strain proved to be the most satisfactory, probably because it had been regularly passed through fowls for several years, acquiring in this wise a more uniform biological behavior with respect to infectivity, resistance to environment, response to available food material, tenure of survival, and apparent readiness to multiplication.

The fact that this strain was carried through thirty-one generations for one hundred twelve days with little or no deterioration in its virulence for susceptible birds proves that the virus lived and multiplied in the medium employed. Such survival and propagation of the virus were further proved by the fact that each transfer or subplant suffered a dilution of 1 to 30, approximately. The rate of multiplication might be expressed by the figures (1:30).[31] Results obtained from the use of single tissue or whole-embryo pulp as medium did not show evidence of tissue predilection insofar as survival and multiplication of the virus were concerned. Simple and compound tissue media were equally satisfactory for propagation.

That the immunity induced by the culture virus did not differ from that which followed the inoculation of natural virus, was shown by the birds that recovered from the culture virus and later resisted a test inoculation of virulent saliva. Moreover, vaccines prepared from culture virus induced an active immunity in susceptible birds which later withstood fatal doses of natural virus. Although this was tried on a few birds only, culture virus gives promise in the preparation of a potent vaccine.

Slide cultures of embryonic and adult tissues failed to reveal intracellular changes of great significance aside from nuclear pyknosis of the skin epithelium. This failure, however, might be due to the fact that a suitable staining method has not yet been devised. Improved tinctorial technic may disclose such changes.

CONCLUSIONS

1. Avian-pest virus was cultivated in a medium consisting of chick-embryo tissue and plasma for thirty-one generations over a period of one hundred twelve days. In such medium the rate of multiplication was expressed by the figures (1 : 30).[31]

2. Culture virus did not seem to differ from natural virus in its ability to induce active immunity as shown by the susceptible birds immunized with the former and which resisted the injection of the latter.

3. A vaccine prepared from culture virus gave promise for the development of an active immunizing agent.

4. Culture virus tolerates a considerable amount of contamination, which denotes a high degree of resistance to bacterial encroachment.

5. Beyond a nuclear pyknosis of the epithelial cells, no intracellular change of great significance was noted in growing tissue cells in the presence of active virus.

ACKNOWLEDGMENT

Thanks are due Dr. E. C. Farinas for supplying a virus strain; Major Raymond Randall, United States Army Medical Department Research Board, for the Stotsenberg virus; and Dr. A. B. Coronel for technical assistance in this work.

REFERENCES

1. CARRELL, A., and T. M. RIVERS. La fabrication du vaccine in vitro. Compt. rend. Soc. Biol. 96 (1927) 848.
2. DOCHEZ, A. R., K. C. MILLS, and Y. KNEELAND. Study of the virus of common cold and its cultivation in tissue medium. Proc. Soc. Exp. Biol. and Med. 28 (5) (1931) 513.
3. FARINAS, E. C. Avian pest, a disease of birds hitherto unknown in the Philippine Islands. Philip. Journ. Agr. 1 No. 4 (1930) 311.
4. FUKUSHIMA, T., K. SHIMOMURA, and S. OYAMA. Pathologische Anatomie der durch ein Filtrierbares Virus Verursachten Hühnerseuche in Korea. Journ. Jap. Vet. Sci. 11 No. 4 (1932) 302.
5. HALLAUER, C. Ueber das Verhalten von Hühnerpestvirus in der Gewebekultur. Ztschr. Hyg. u. Infektkr. 113 (1931) 61 (21 refs.).
6. HECKE, F. Züchtungsversuche des Maul und Klauenseuchevirus in Gewebekulturen. Zentrbl. Bakt. I, Abt. Orig. 116 (6/8) (1930) 386.
7. HECKE, F. Die künstliche Vermehrung des Schweinepestvirus mittels Gewebekulturen (The artificial cultivation of swine fever virus). Zentrlbl. Bakt. 1 Abt. Orig. 126 (1932) 517.
8. LEVADITI, C. Virus rabique et culture des cellules in vitro. Compt. rend. Soc. Biol. 75 (1913) 505.
9. PARKER, Jr., F., and R. N. NYE. I. Studies on filterable viruses. Am. Journ. Path. 1 (1925) 352.
10. PINKERTON, H., and G. M. HAAS. Typhus fever in tissue culture. The behavior of Ricketsia Prowazeki in tissue cultures. Journ. Exp. Med. 43 No. 3 (1931) 307.
11. PLOTZ, H. Culture de la peste aviaire en presence de cellules embryonaires vivantes. Comp. rend. Soc. Biol. 170 (1932) 163 (2 refs.).
12. STEINHARDT, E., C. ISRAELI, and R. A. LAMBERT. Studies on the cultivation of the virus of vaccinia. Journ. Exp. Med. 40 II (1913) 281.

THE NATURAL ENEMIES OF ALEYRODIDÆ IN TROPICAL ASIA[1]

By C. P. Clausen

Senior Entomologist, United States Department of Agriculture, Washington

During the course of the investigations upon the natural enemies of the citrus blackfly (*Aleurocanthus woglumi* Ashby) in tropical Asia from 1929 to 1931, inclusive, observations were also made upon the species attacking other members of the family Aleyrodidæ. These observations were most extensive in Malaya, Java, and Sumatra, but advantage was taken of limited opportunities for study in the Philippine Islands, Siam, Burma, and Ceylon. A number of the host species noted in tropical Asia are of economic importance, and two of them, *Aleurocanthus woglumi* in Cuba and tropical America(1) and *A. spiniferus* Quaintance in Japan,(3) have been effectively controlled by parasite introductions. Other species are major pests also, and a record of their natural enemies is of value in case projects on their biological control are contemplated.

In 1927 F. Silvestri(5) published an account of the Aleyrodidæ infesting citrus trees in the Far East, giving extensive records of the natural enemies attacking them. The majority of species collected were described by him as new. The present paper deals largely with the host relationships and distribution of the parasite species listed by Silvestri which are found in the tropical part of Asia, and, in addition, records a number of other parasites and predators on this group of insects.

The list of host species is given below, and under each are given the various natural enemies which have been found to attack it. The starred species have been collected by the author; the remainder are based upon published records.

---

[1] The identifications of the insects listed herein have been made by the Division of Identification and Classification of Insects of the United States Bureau of Entomology, the Coleoptera being determined by E. A. Chapin, the Lepidoptera by Carl Heinrich, the Diptera by J. M. Aldrich, the Hymenoptera by A. B. Gahan, and the Aleyrodidæ by P. W. Mason and also by A. C. Baker of the Division of Fruit and Shade Tree Insects.

NATURAL ENEMIES OF ALEYRODIDÆ

ALEUROCANTHUS CITRIPERDUS Quaintance and Baker.

Upon citrus in southern China, Malaya, the Dutch East Indies, and Ceylon.

Parasites:

- * *Amitus hesperidum* Silvestri; Platygasteridæ.
- * *Amitus hesperidum* subsp. *variipes* Silvestri; Platygasteridæ.
- * *Encarsia merceti* Silvestri; Eulophidæ.
- * *Eretmocerus serius* Silvestri; Eulophidæ.
- * *Prospaltella divergens* Silvestri; Eulophidæ.
- * *Prospaltella smithi* Silvestri; Eulophidæ.
- * *Prospaltella* sp.; Eulophidæ.

Predators:

- * *Acletoxenus indica* Malloch; Drosophilidæ.
- * *Acletoxenus* sp. nov.; Drosophilidæ.
- * *Chrysopa* sp.; Chrysopidæ.
- * *Cryptoblabes gnidiella* Millière; Pyralidæ.
- * *Cybocephalus* sp.; Nitidulidæ.
- * *Scymnus smithianus* Silvestri; Coccinellidæ.
- * *Scymnus* sp.; Coccinellidæ
- * *Scymnus* sp.; near *pallidicollis* Mulsant; Coccinellidæ.

ALEUROCANTHUS INCERATUS Silvestri.

On citrus in Indo-China.

Parasites:

- *Prospaltella clypealis* Silvestri; Eulophidæ.
- *Prospaltella opulenta* Silvestri; Eulophidæ.

Predator:

- *Scymnus* sp.; Coccinellidæ.

ALEUROCANTHUS LONGISPINUS Quaintance and Baker.

Upon bamboo in Malaya.

Parasites:

- * *Eretmocerus serius* Silvestri; Eulophidæ.
- * *Prospaltella divergens* Silvestri; Eulophidæ.

ALEUROCANTHUS SPINIFERUS Quaintance.

Upon citrus and ornamental trees throughout subtropical and tropical Asia.

Parasites:

- *Amitus hesperidum* subsp. *variipes* Silvestri; Platygasteridæ.
- *Amitus* sp.; Platygasteridæ.
- * *Encarsia merceti* Silvestri; Eulophidæ.
- * *Eretmocerus serius* Silvestri; Eulophidæ.
- * *Prospaltella divergens* Silvestri; Eulophidæ.
- *Prospaltella ishii* Silvestri; Eulophidæ.
- * *Prospaltella smithi* Silvestri; Eulophidæ.
- * *Prospaltella* sp.; Eulophidæ.

Predators:
- * *Acletoxenus indica* Malloch; Drosophilidæ.
- * *Acletoxenus* n. sp. nov.; Drosophilidæ.
- *Chrysopa fulvolineata;* Chrysopidæ.
- * *Chrysopa* sp.; Chrysopidæ.
- * *Cryptognatha* sp. nov.; Coccinellidæ.
- *Delphastus* sp.; Coccinellidæ.
- * *Scymnus* sp.; near *pallidicollis* Mulsant; Coccinellidæ.

ALEUROCANTHUS SPINOSUS (Kuwana).

Upon *Anona* sp. and *Hibiscus* sp. at Manila, Philippine Islands.

Parasites:
- * *Prospaltella clypealis* Silvestri; Eulophidæ.
- * *Prospaltella* sp. nov.; Eulophidæ.

Predator:
- * *Scymnus* sp.; Coccinellidæ.

ALEUROCANTHUS WOGLUMI Ashby.

Upon citrus and occasional other trees throughout subtropical and tropical Asia.

Parasites:
- * *Encarsia merceti* Silvestri; Eulophidæ.
- * *Eretmocerus serius* Silvestri; Eulophidæ.
- * *Prospaltella divergens* Silvestri; Eulophidæ.
- * *Prospaltella smithi* Silvestri; Eulophidæ.
- * *Prospaltella* sp.; Eulophidæ.

Predators:
- * *Acletoxenus indica* Malloch; Drosophilidæ.
- * *Acletoxenus* sp. nov.; Drosophilidæ.
- * *Chrysopa* sp.; Chrysopidæ.
- * *Cryptoblabes gnidiella* Millière; Pyralidæ.
- * *Cryptognatha* sp. nov.; Coccinellidæ.
- * *Scymnus smithianus* Silvestri; Coccinellidæ.
- * *Scymnus* sp.; Coccinellidæ.
- * *Scymnus* sp.; near *pallidicollis* Mulsant; Coccinellidæ.
- * *Cybocephalus* sp.; Nitidulidæ.

ALEUROCANTHUS sp.

On *Anona* sp. at Singapore, Straits Settlements.

Parasites:
- * *Prospaltella clypealis* Silvestri; Eulophidæ.
- * *Prospaltella* sp. nov.; Eulophidæ.

Predator:
- * *Scymnus* sp.; Coccinellidæ.

ALEUROCANTHUS sp.

Upon citrus at Medan, Sumatra.

Parasites:
- * *Eretmocerus serius* Silvestri; Eulophidæ.
- * *Prospaltella divergens* Silvestri; Eulophidæ.
- * *Prospaltella* sp. nov.; Eulophidæ.

Predator:
- * *Scymnus* sp.; near *pallidicollis* Mulsant; Coccinellidæ.

ALEUROCYBOTUS SETIGERUS Quaintance and Baker.

On *Pandanus* at Manila, Philippine Islands.
Parasite:
Encarsia persequens Silvestri; Eulophidæ.

ALEUROLOBUS SUBROTUNDUS Silvestri.

Upon citrus in Indo-China.
Parasite:
Prospaltella armata Silvestri; Eulophidæ.

ALEUROPLATUS sp.

Upon *Ficus religiosa* Linnæus at Singapore, Straits Settlements.
Parasites:
* *Eretmocerus* sp. nov.; Eulophidæ.
* *Prospaltella strenua* Silvestri; Eulophidæ.
Predator:
* *Scymnus* sp.; Coccinellidæ.

ALEYRODES RICINI Misra.

On castor in India.
Parasites:
Aphelinus fuscipennis Howard; Eulophidæ.
Prospaltella lahorensis Howard; Eulophidæ.
Prospaltella sp.; Eulophidæ.
Predator:
Chrysopa sp.; Chrysopidæ.

ALEYRODES sp.

Upon *Sauropus androgynus* Merrill at Singapore, Straits Settlements.
Parasite:
* *Eretmocerus* sp. nov.; Eulophidæ.
Predators:
* *Scymnus* sp.; Coccinellidæ.
* *Scymnus* sp.; near *pallidicollis* Mulsant; Coccinellidæ.

ASTEROCHITON sp.

Upon citrus in Java and at Singapore, Straits Settlements.
Parasite:
* *Prospaltella strenua* Silvestri; Eulophidæ.

BEMISIA GIFFARDI Kotinsky.

Upon citrus in Malaya, Java, and Sumatra.
Parasite:
* *Prospaltella strenua* Silvestri; Eulophidæ.

DIALEURODES CITRI (Ashmead).

On citrus and ornamentals in Japan, China, and India.
Parasites:
Prospaltella citrofila Silvestri; Eulophidæ.
Prospaltella lahorensis Howard; Eulophidæ.
Predators:
Brumus suturalis Fabricius; Coccinelidæ.
Cryptognatha flavescens Motsch.; Coccinellidæ.
Serangium sp.; Coccinellidæ.

DIALEURODES CITRIFOLII (Morgan).

On citrus in Indo-China.
Parasites:
Prospaltella perstrenua Silvestri; Eulophidæ.
Prospaltella strenua Silvestri; Eulophidæ.

DIALEURODES EUGENIAE Maskell.

Upon *Eugenia* spp. in Java and Sumatra.
Parasite:
* *Prospaltella strenua* Silvestri; Eulophidæ.

NEOMASKELLIA BERGII (Signoret).

Upon sugar cane at Singapore, Straits Settlements.
Parasites:
* Platygasteridæ (an undetermined species).
Prospaltella tristis Zehntner; Eulophidæ.
Predator:
Scymnus sp.; Coccinellidæ.

THE HOST SPECIES

The Aleyrodidæ of tropical Asia are exceptionally abundant in the number of species that occur upon native shrubs and trees. With the great majority of species the numerical level is quite low, although with a smaller number, particularly of the genus *Aleurocanthus,* the status of a major pest is occasionally attained. This genus is perhaps the dominant one of the family in tropical Asia, and *A. spiniferus, A. citriperdus,* and *Aleurocanthus* sp., at times heavily infest citrus trees in that region. This applies to a lesser extent to *A. woglumi* also. *Aleurocanthus spinosus* is often very abundant on *Anona* and *Hibiscus* in the Philippine Islands.

The seasonal abundance of the above species is quite largely determined by climatic conditions. *Aleurocanthus woglumi* suffers a high mortality during periods of relatively low humidity and scant rainfall, whereas *A. citriperdus* flourishes during these periods and is then greatly reduced by fungus attack during the rainy season. This reaction to climatic conditions has a close relationship to the effectiveness of parasite attack. Those host species which attain maximum abundance during the rainy season are in general more effectively attacked by the various natural enemies. In the case of *A. woglumi* the optimum conditions for the host and the parasites are the same, and maximum effectiveness of the latter is secured. In Malaya and the Dutch East Indies an exceptionally large number of parasite species are found to attack practically every species of the genus. Five parasites and nine predators were found attacking *A. wog-*

lumi in that region. A similar condition exists with respect to the other species that occur there.

The genus *Aleyrodes* is not at all common in tropical Asia, at least in so far as the occurrence of appreciable infestations is concerned; and only a single species, as yet undetermined, was found in sufficient numbers to permit of collection in quantity for parasite rearings. This species occurs upon *Sauropus androgynus* Merrill at Singapore. Occasional plants are heavily infested, but the colonies seen were soon greatly reduced by attack of the various natural enemies.

Misra(4) records *Aleyrodes ricini* as a pest of castor (*Ricinus communis* L.) in India. It is of general distribution throughout the country and at times becomes a serious pest.

Several species of *Dialeurodes* were noted upon citrus and other plants in the Malayan region, though usually in limited numbers. The commonest was an undetermined and possibly new species upon pummelo at Medan, Sumatra. Conspicuous by its absence was *D. citri,* which has nearly world-wide distribution. Only one species of this genus showed any evidence of parasitization, this being *D. eugeniæ* upon *Eugenia* sp. in Java and Sumatra. Both sides of the leaves were heavily infested, the lower more heavily than the upper, and a considerable number of the pupal cases showed parasite emergence holes. The one species of which specimens were secured was *Prospaltella strenua.*

Dialeurodes citri is occasionally found quite abundant upon citrus hedges and orchard trees in India, though only under well-shaded conditions. It has also been recorded as occurring upon several ornamental plants. Woglum(6) gives an account of the habits of this species in India, and of the search made for its natural enemies in the Far East. It occurs generally throughout India, though never as a commercial pest, and is also recorded from China and Japan.

The general ineffectiveness of natural control of the species of this genus is in marked contrast to that shown in the case of the species of *Aleurocanthus.*

The single species of *Aleuroplatus* observed was present in great abundance upon the foliage of *Ficus religiosa* at Singapore. Natural enemies were present in considerable numbers, but they were not appreciably effective, as a population approaching the maximum persisted upon the foliage.

An undetermined species of *Asterochiton* was noted upon citrus throughout Java and at Singapore. The infestation was relatively light and confined almost entirely to the young foliage of water sprouts growing from the base or the lower part of the trunk of the tree. A large percentage of individuals showed parasite attack; in fact, in eastern Java it was difficult to find unparasitized pupæ. Natural control was apparently consistently effective.

Bemisia giffardi was noted in small numbers upon citrus in Malaya and in Java and Sumatra. Occasional individuals of a single parasite species, *Prospaltella strenua,* were reared from the pupæ, but the numbers of the host secured were too small to give an indication of the extent to which the parasite was responsible for this numerical scarcity.

A pest of sugar cane, *Neomaskellia bergii,* which is of some economic importance in certain sections of tropical Asia, was noted in small numbers at Singapore. A large percentage of the pupal cases showed multiple parasite-emergence holes. Natural control appeared to be fully effective throughout the season. No adult parasites were secured from the material collected, and a determination is therefore not possible. Dammerman (2) records *Prospaltella tristis* as often heavily parasitizing this host in Java.

THE PARASITES

In number of species and in general effectiveness the genus *Prospaltella* is dominant among the parasites of Aleyrodidæ in tropical Asia. The genus is particularly well represented among the parasites of *Aleurocanthus,* and every species of that genus encountered showed attack by one or more species of *Prospaltella. Prospaltella divergens* is the most prominent member of the genus in Malaya and the Dutch East Indies and is largely responsible for the natural control of *Aleurocanthus woglumi* in that section. Occasionally it may be superseded by *Eretmocerus serius.* The distribution of *P. divergens* is apparently limited to Malaya and the Dutch East Indies. This species normally reproduces parthenogenetically, a habit not general in the genus. An unsuccessful effort was made to establish this parasite upon *A. woglumi* in Cuba.

In addition to the above host *P. divergens* was also found abundant upon *A. citriperdus, A. longispinus, A. spiniferus,* and *Aleurocanthus* sp.

Prospaltella lahorensis is recorded by Woglum (6) as a parasite of *Dialeurodes citri* in India, and an attempt was made to effect its introduction into the United States for the control of that pest. It has since been recorded by Misra(4) as attacking *Aleyrodes ricini.*

Prospaltella citrofila is recorded by Silvestri(5) as a parasite of *Dialeurodes citri* in Indo-China, while *P. perstrenua* upon *Dialeurodes citrifolii* and *P. armata* upon *Aleurolobus subrotundus* are found in the same country.

Prospaltella smithi was found as a parasite of *Aleurocanthus citriperdus, A. spiniferus,* and *A. woglumi* in Malaya, the Dutch East Indies, and Ceylon. It is recorded by Silvestri from southern China. This species was introduced into Japan in 1925 and is reported to have effectively controlled a heavy infestation of *A. spiniferus* in that country. Under normal conditions in Malaya, *P. smithi* is the third most abundant of the parasites of *A. woglumi,* and only occasionally does it assume a dominant status.

In the Philippine Islands *Aleurocanthus spinosus* is rather heavily parasitized by *Prospaltella clypealis,* and the same parasite was reared from *Aleurocanthus* sp. on *Anona* at Singapore. Silvestri originally described the species from Indo-China as a parasite of *Aleurocanthus inceratus* Silvestri on citrus.

Prospaltella strenua was found to occur in Malaya and the Dutch East Indies upon *Aleuroplatus* sp., *Asterochiton* sp., *Dialeurodes eugeniae,* and *Bemisia giffardi.* The material upon which the species was described by Silvestri was reared from *Bemisia giffardi* collected at Macao in southern China. It is also recorded from *Dialeurodes citrifolii* in Indo-China. In Malaya and Java this parasite is particularly abundant and effective against *Asterochiton* sp. on citrus and *Dialeurodes eugeniae* on *Eugenia* spp. It was difficult to find unparasitized pupæ of the former host. In view of the range of host genera covered by this parasite, it would appear probable that it would be a useful enemy of *Dialeurodes citri,* which is an important pest of citrus in Florida and elsewhere. This host, however, is not known to occur in the Malayan region, consequently no observations could be made upon it. Silvestri does not record *P. strenua* upon this host in southern China.

Several additional species of *Prospaltella,* as yet undetermined or undescribed, have been reared from *Aleurocanthus spinosus* in the Philippine Islands; *A. citriperdus, A. spiniferus,* and *A. woglumi* at Medan, Sumatra; *A. woglumi* at Colombo, Ceylon; *Aleyrodes ricini* in India, and one or two others from *Aleurocanthus* spp. at Singapore and at Medan, Sumatra.

Encarsia merceti is common, though not abundant, as a parasite of *A. woglumi* in Malaya and the Dutch East Indies. It was also reared from *A. citriperdus* and *A. spiniferus* in the same region, and was originally described from *A. woglumi* collected at Singapore. *Encarsia persequens* is recorded by Silvestri as a parasite of *Aleurocybotus setigerus* at Manila, Philippine Islands.

Eretmocerus serius ranks next in importance to *P. divergens* as a parasite of *Aleurocanthus* in Malaya and the Dutch East Indies. It has been collected also in Siam, Burma, and Ceylon upon *A. woglumi*, and has also been reared from *A. citriperdus*, *A. spiniferus*, *A. longispinus*, and *Aleurocanthus* sp., the latter host being only upon citrus at Medan, Sumatra. An extended account of the biology of this species has been presented in an earlier publication.(1) All aleyrodid parasites previously studied have proved to be of true internal habit, but this species departs from that custom by depositing its eggs upon the leaf surface beneath the host larva, the parasite larva then feeding externally during its first two instars, after which it enters the host's body immediately after the latter has transformed to the pupal stage. Two generations are produced upon each generation of the host. The parasite was introduced into Cuba and various other countries in tropical America in 1930 and succeeding years, and has been completely successful in the control of *Aleurocanthus woglumi.*

An undescribed species of *Eretmocerus* occurs abundantly as a parasite of *Aleuroplatus* sp. on *Ficus religiosa* at Singapore, though not sufficiently effective to control the host. Another new species occurs upon *Aleurodes* sp. infesting *Sauropus androgynus* at Singapore. Shortly after the first observations upon it the entire infestation very largely disappeared, the parasite probably being the dominant factor in its reduction.

The genus *Eretmocerus* includes an exceptional number of species which are capable of effectively controlling their hosts. *Eretmocerus haldemani* Howard is credited with effectively controlling the woolly white fly (*Aleurothrixus howardi* Quaintance) in Florida and Cuba. In all the species observed there has been shown an exceptional adaptation to environmental conditions. The females are unusually active in the search for hosts, and this results in a high rate of parasitization even where the host is scarce. This, in conjunction with the development of two generations to each generation of the host, insures a sufficiently high population at all times to check rapidly any incipient outbreak.

The platygasterid *Amitus hesperidum* was reared in considerable numbers from *Aleurocanthus citriperdus* in eastern Java, the extent of parasitization in some infestations approaching 50 per cent. Silvestri records it upon the above host at Hongkong and at Singapore.

The subspecies *A. hesperidum variipes,* described by Silvestri from *Aleurocanthus spiniferus* collected at Sanshaci, Changsha, China, was found to be very abundant in Sumatra upon *A. citriperdus* at Brastagi (elevation 4,500 feet), but was not seen in the infestations near sea level. Although the percentage of parasitization as revealed by an examination of the pupal cases was rather high, yet the host population at the time of examination was very nearly the maximum possible. Six months later, however, the trees were practically free from infestation. At the time of the first examination the adult parasites were present in abundance upon the foliage, and the host species was very largely in the egg stage, with extensive hatching taking place. The parasite females were very actively engaged in ovipositing in these newly hatched larvæ, preferably those which had not yet settled and were still lacking the black pigmentation, though larvæ which had already begun feeding were also attacked. In contrast to this, Silvestri records females of *A. hesperidum* as apparently ovipositing in the host pupæ.

Amitus sp. is recorded as parasitic upon *Aleurocanthus spiniferus* in southern Japan.

HYPERPARASITES

In all of the rearings of aleyrodid parasites made in the course of these investigations the hyperparasites recorded were all restricted to the single genus *Ablerus.* All species of *Aleurocanthus* collected in Siam, Malaya, and the Dutch East Indies yielded large numbers of *Ablerus machrochaeta* subsp. *inquirenda* Silvestri, which evidently attacks indiscriminately all of the primary parasites of the genus *Aleurocanthus.* The mortality effected among these parasites was estimated at approximately 50 per cent. Occasional individuals were reared from *Amitus hesperidum* parasitic upon *Aleurocanthus citriperdus* in eastern Java, and from the variety *variipes* on the same host at Brastagi, Sumatra. This hyperparasite apparently is restricted to the parasites of *Aleurocanthus. Ablerus machrochaeta* Silvestri was described from material reared from *Aleurocanthus inceratus* in Indo-China and was presumed to be parasitic upon *Prospaltella opulenta.* It is also recorded from southern China upon

A. spiniferus. Ablerus connectans Silvestri was found to be as abundant in Ceylon as is the first-named species in the Malayan region. Dammerman (2) lists *A. pulchriceps* Zehntner as a parasite of *Aleurolobus longicornis* Zehntner in Java, but it more probably develops upon other parasites of this host.

THE PREDATORS

Several coccinellids are found from time to time attacking the various species of Aleyrodidæ, but it is very seldom that they exert an influence comparable to that of the internal parasites. The commonest of these species is *Scymnus* sp., near *pallidicollis*, which occurs in practically every infestation, though usually in small numbers. Its preferred host is *Aleurocanthus citriperdus*, and only a very few were found attacking *A. woglumi*. It occurs also in infestations of other genera of Aleyrodidæ. The adult beetles feed largely upon the early larval instars, while the larvæ feed upon all the larval instars and upon the pupæ also. The mature larvæ carry upon the body a dorsal shield built up of the cast skins of the host which have become entangled in the long body hairs.

Several undetermined species of *Scymnus* occur generally throughout tropical Asia as occasional predators upon Aleyrodidæ and upon several diaspine Coccidæ also. They were noted to attack *Aleurocanthus*, *Aleuroplatus*, and *Aleyrodes*.

Scymnus smithianus, predacious upon *Aleurocanthus citriperdus* and *A. woglumi*, was found only in the single locality of Kaban Djahné, Sumatra (elevation 4,200 feet). The larvæ are distinguishable from others attacking Aleyrodidæ by the black transverse segmental bands on the dorsum. Both larvæ and pupæ of *S. smithianus* are heavily attacked by *Aminellus* sp. nov. near *niger* Masi. This coccinellid was introduced into Cuba in 1930 for colonization upon *A. woglumi*, and apparently became established, though only small numbers could be found in the field.

Small colonies of *Cryptognatha* sp. nov.[2] were found in isolated localities in the Malayan region, one feeding upon *A. woglumi* at Kuala Lumpur, Federated Malay States, and another upon *A. spiniferus* at Medan, Sumatra. The adult beetles and larvæ may feed exclusively upon the eggs where the host is largely in that stage, or upon the larvæ and pupæ. The pupal stage is passed in the soil or in rubbish beneath the tree. This predator was introduced into Cuba in 1930 and soon became established in the groves infested with *A. woglumi.* In several instances complete control was effected in heavily infested groves within three to five months after liberation of the beetles. Such a result, however, is only occasional, and greater reliance has been placed upon the eulophid parasite *Eretmocerus serius.* A species of *Cryptognatha*(3) was introduced into Japan from southern China as a predator of *Aleurocanthus spiniferus. Cryptognatha flavescens* is recorded by Woglum(6) as a predator of *Dialeurodes citri* in India, and an attempt was made to introduce it into the United States for the control of this pest.

---

[2] With reference to this group Dr. E. A. Chapin says: "The names in current use for the coccinellids related to *Cryptognatha* are retained in this paper. It is probable that the species here referred to *Cryptognatha*, *Serangium*, and *Delphastus* are all subject to generic reassignment."

Other coccinellid predators recorded as attacking Aleyrodidæ are *Serangium* sp. upon *Dialeurodes citri* in Japan and *Brumus suturalis* on the same host in India.

The nitidulid *Cybocephalus* sp. was found in only a single instance as a predator of Aleyrodidæ. This was in a mixed infestation of *Aleurocanthus citriperdus* and *A. woglumi* upon an orange tree at Buitenzorg, Java. All stages were present in considerable numbers. The larvæ are white and greatly resemble those of *Scymnus,* though they bear no dorsal covering of cast skins. They are sluggish and seldom leave the leaf upon which they first start feeding. Pupation takes place in a cell in the soil.

The dipterous family Drosophilidæ includes a number of species which are predacious upon Aleyrodidæ. *Acletoxenus indica* was found to be rather common in infestations of various species of *Aleurocanthus* and other genera in Java. Where several host species were present upon the same or adjoining trees a marked preference was shown for *A. citriperdus.* At Bandoeng, Java, *indica* was the most abundant of all predators upon the above host. The eggs are deposited among the host clusters and the *Acletoxenus* larvæ feed largely on the mature larvæ and pupæ, finally pupating upon the leaf surface. The puparia of *Acletoxenus* are heavily parasitized by *Myiocnema* sp. *Acletoxenus* sp. nov. was found to attack *Aleurocanthus citriperdus* and *A. woglumi* at Kaban Djahné, Sumatra, and empty puparia of some species of this genus were found among aleyrodid clusters in Malaya and Ceylon.

In practically every section larvæ of the Chrysopidæ are recorded as feeding upon the Aleyrodidæ, and often they are dominant among the predators attacking them. In only one instance has the species been determined, this being *Chrysopa fulvolineata* attacking *Aleurocanthus spiniferus* in India.

The pyralid moth *Cryptoblabes gnidiella* was observed as an occasional predator on *Aleurocanthus citriperdus* and *A. woglumi* in Malaya and Sumatra. The larvæ feed upon the advanced stages of the host, and they may assume the rôle of scavengers also. In view of the record of its being a plant feeder in Egypt and southern Europe, and of its being possibly a predator on the cotton bollworm (*Earias insulana* Boisduval) in Egypt, *C. gnidiella* appears to be lacking in a fixity of habit.

LITERATURE CITED

1. Clausen, C. P., and P. A. Berry. The citrus blackfly in Asia, and the importation of its natural enemies into tropical America. U. S. Dept. Agr. Tech. Bull. 320 (1932) 58 pp., illus.
2. Dammerman, K. W. The agricultural zoölogy of the Malay Archipelago: the animals injurious and beneficial to agriculture, horticulture and forestry in the Malay Peninsula, the Dutch East Indies and the Philippines. J. H. de Bussy, Ltd., Amsterdam (1929) 473 pp., illus.
3. Kuwana, I., and T. Ishii. On Prospaltella smithi Silv. and Cryptognatha sp., the enemies of Aleurocanthus spiniferus, imported from Canton, China. Jl. Okitsu Hort. Soc., No. 22 (1927) 77–80, illus. (In Japanese.)
4. Misra, C. S. The citrus white-fly, Dialeurodes citri, in India and its parasites, together with the life-history of Aleyrodes ricini n. sp. Rept. Fifth Ent. Meeting, Pusa, 1923 (1924) 129–135.
5. Silvestri, F. Contribuzione alla conoscenza degli Aleurodidae (Insecta: Hemiptera) viventi su citrus in Estremo Oriente e dei loro parassiti. Boll. Lab. Zool. Gen. e Agr. Portici 21 (1927) 1–60, illus.
6. Woglum, R. S. Report of a trip to India and the Orient in search of the natural enemies of the citrus white fly. U. S. Dept. Agr., Bur. Ent., Bull. 120 (1913) 58 pp., illus.

NEW OR LITTLE-KNOWN TIPULIDÆ FROM EASTERN ASIA (DIPTERA), XVIII[1]

By Charles P. Alexander
Of Amherst, Massachusetts

THREE PLATES

The crane flies discussed herein have been derived from a variety of sources, but chiefly from western China, where they were collected by the Rev. Mr. George M. Franck, and from Japan and Formosa, where taken by Mr. Syûti Issiki. Types of such species are preserved in my collection, through the kind interest of the collectors. Other specimens discussed are included in the Russian Academy of Sciences, Leningrad, through Drs. Pleske and von Stackelberg; in the Macleay Collection of the University of Sydney, through Mr. Frank H. Taylor; Federal Collection at Canberra, Australia, through Dr. Ian Mackerras; Bishop Museum, Honolulu, through Mr. Edwin H. Bryan; and Sumatran material collected by Mr. Edward Jacobson, now preserved in the United States National Museum, through the interest of the collector. As before, I am greatly indebted to all of the scientists mentioned, for their continued interest in saving these flies.

Among the Tipulidæ collected by Mr. Issiki in Hokkaido and Honshiu, Japan, were included a number of interesting records that are listed herewith.

Sôunkyô, Hokkaido, June 4, 1932 (*S. Issiki*).

Limonia (*Limonia*) *fusca* Meigen.
Pedicia (*Nasiternella*) *hokkaidensis* sp. nov.
Pedicia (*Tricyphona*) *optabilis* Alexander.
Pedicia (*Tricyphona*) *seticauda* Alexander.
Dicranota (*Rhaphidolabis*) *spina* Alexander.
Pseudolimnophila mobilis sp. nov.
Limnophila (*Prionolabis*) *sounkyana* sp. nov.
Ormosia takeuchii Alexander.

---

[1] Contribution from the entomological laboratory, Massachusetts State College.

Yumoto, Shimotsuke, Honshiu, altitude 4,850 feet, June 20, 1932 (S. Issiki).

Limonia (*Limonia*) *euphileta* Alexander.
Dicranota (*Rhaphidolabis*) *platymera* sp. nov.
Pseudolimnophila yumotana sp. nov.
Limnophila (*Limnophila*) *japonica* Alexander.
Limnophila (*Tricholimnophila*) *prionolaboides* sp. nov.
Ormosia rectangularis sp. nov.
Erioptera (*Hoplolabis*) *asiatica* Alexander.
Molophilus pegasus Alexander.
Molophilus triacanthus sp. nov.

Lake Chuzenji, Shimotsuke, Honshiu, altitude 4,100 feet, June 22, 1932 (S. Issiki).

Pseudolimnophila erecta sp. nov.
Limnophila (*Prionolabis*) *inermis* sp. nov.
Limnophila (*Prionolabis*) *odai* Alexander.
Limnophila (*Tricholimnophila*) *saitamæ* Alexander.

Konseitoge, Shimotsuke, Honshiu, altitude 5,200 to 6,500 feet, June 21, 1932 (S. Issiki).

Limonia (*Dicranomyia*) near *depauperata* Alexander.
Pseudolimnophila erecta sp. nov.
Limnophila (*Prionolabis*) *luteibasalis* sp. nov.

LIMONIINÆ

LIMONIINI

LIMONIA (LIMONIA) FUSCA Meigen.

Limonia fusca MEIGEN, Klassification 1 (1804) 54.
Limnobia turpis WALKER, Insecta Britannica, Diptera 3 (1856) 300.
Dicranomyia pubipennis OSTEN SACKEN, Proc. Acad. Nat. Sci. Philadelphia for 1859 (1859) 211.
Limnobia pilipennis EGGER, Verh. Zool.-Bot. Ges. Wien 13 (1863) 1108.

Two males, Sôunkyô, Hokkaido, Japan, June 4, 1932 (*S. Issiki*). This wide-spread Holarctic crane fly has not hitherto been recorded from eastern Asia.

LIMONIA (LIBNOTES) FIJIENSIS DELANDI subsp. nov.

Male.—Length, about 6 millimeters; wing, 7.

Sclerites of mesonotum behind the transverse suture almost uniformly darkened. Wings with dark pattern reduced, the stigma much smaller than in males of typical *fijiensis*. Venation: Sc long, Sc_1 ending beyond r-m, Sc_2 some distance from its tip, opposite fork of Rs; Rs unusually short and only slightly arcuated, about two-thirds as long as the corresponding vein in *fijiensis*. Male hypopygium with the caudal border of tergite evenly, convexly rounded, with a tiny median notch; setæ at the exact border, those nearest the median notch more or less decussate. Basistyle with ventral-apical lobe long and slender, exceeding in length the basistyle itself, with four or five setæ at midlength more elongate and powerfully constructed; apex of lobe microscopically transverse-corrugated. Dististyle broad, at base with a small bisetiferous tubercle and a tiny acute spine; apical teeth approximated, the outer one slender. Gonapophyses elongate.

Habitat.—Santa Cruz Islands.

Holotype, male, Vanikoro Island (*C. M. Deland*). Received through Mr. Frank H. Taylor, to whom the type has been returned.

The present fly seems to be closest to *Limonia* (*Libnotes*) *fijiensis hebridensis* (Edwards), of New Hebrides, differing in the even shorter Rs and in the details of the male hypopygium. Whether the *fijiensis* group will be found to include several closely allied and vicarious species (as *toxopei* Edwards, of Buru; *veitchiana* Edwards, of Fiji, additional to the forms mentioned above) or whether these are best considered as being geographic races, cannot be affirmed without much more material than has yet been available. Edwards[2] has reported a variety of *fijiensis* from Samoa. He describes the apical lobe of the basistyle as being much shorter than in *fijiensis*, as figured by me,[3] whereas in the present fly it is distinctly longer.

LIMONIA (DICRANOMYIA) AMURENSIS (Alexander).

Dicranomyia amurensis ALEXANDER, Proc. U. S. Nat. Mus. 68 art. 4 (1925) 5–6, fig. 1 (male hypopygium).

Described from a single male, Amagu Village, Ussuri, July 1923 (*T. D. A. Cockerell*). An additional male, Kuegda, Saghalien, July 10, 1908 (*W. Soldatov*); Academy of Sciences, Leningrad.

A few supplementary notes are given: Thoracic pleura gray, the dorsopleural region more infuscated. Venation: m-cu about one-third its length before fork of M. Male hypopygium about as described and figured in original definition, with certain emendations. Cephalic mesal margin of ventral dististyle, below base of rostral prolongation with a conspicuous group or pencil of setæ. Apex of basistyle on mesal face with a dense group of setæ.

---

[2] Insects of Samoa, Diptera Nematocera (1928) 80–81.

[3] Ann. Ent. Soc. America 7 (1914) 246, fig. 8.

The species is allied to the Nearctic *gibsoni* (Alexander), *hæretica* (Osten Sacken), and *penicillata* (Alexander), but is still very different in the structure of the male hypopygium.

LIMONIA (DICRANOMYIA) PLATYROSTRA (Alexander).

Dicranomyia platyrostra ALEXANDER, Can. Ent. 59 (1927) 223–224, fig. 2 (male hypopygium).

This species was described from the Lesser Slave Lake, Alberta, Canada, taken in mid-August by Owen Bryant. In the Academy of Sciences, Leningrad, a male from Shiveluch Volcano, near Nizchnekamchatsk, Kamchatka, 162° 30′ east longitude, 56° 40′ north latitude, August 27, 1909 (*P. Schmidt*).

This has been compared with the type, and I can see no differences with the single exception that the rostral spines are a little shorter in the present specimen than in the type.

LIMONIA (GERANOMYIA) UNIFILOSA sp. nov. Plate 1, fig. 1; Plate 2, fig. 25.

General coloration of thorax bluish gray, the præscutum with a darker median stripe; head blackish, the posterior vertex with a narrow grayish median line; legs yellow; wings with a brown pattern, including small marginal clouds at ends of outer medial veins; m-cu close to fork of M; male hypopygium with the rostral prolongation bearing a single, very slender spine; gonapophyses with lateral tooth on mesal-apical lobe.

Male.—Length, excluding rostrum, about 6 millimeters; wing, 6.3; rostrum, about 2.

Rostrum black throughout; palpi black. Antennæ black; flagellar segments oval. Head blackish, the posterior vertex with a narrow grayish median line, extending caudad onto the occiput.

Mesonotal præscutum above bluish gray, with deep reddish tints; a broad median blackish stripe, the lateral margins apparently similarly darkened, but the coloration changeable in different lights; posterior sclerites of mesonotum darkened, the scutellum with a darker median area. Pleura blackish, the sternopleurite brightened to reddish. Halteres pale, the knobs dusky. Legs with the coxæ and trochanters yellow, the posterior coxæ somewhat darker; remainder of legs pale yellow, the outer tarsal segments a trifle darker. Wings (Plate 1, fig. 1) broad, the ground color pale brownish; a moderately heavy brown pattern, chiefly costal in distribution, but including smaller marginal spots at ends of all longitudinal veins; second area (at supernumerary crossvein in cell Sc) reaching vein M; stigmal area produced backward to vein R_{4+5}; apical darkenings in outer radial and medial fields forming a broken, nearly terminal band; narrow brown seams along cord and outer end of cell 1st M_2; veins pale yellow, darker in the clouded areas. Venation: Sc_1 ending about opposite three-fourths the length of Rs, Sc_2 near its tip; a supernumerary crossvein in cell Sc; free tip of Sc_2 and R_2 subequal; m-cu close to fork of M.

Abdominal tergites dark brown, sternites more reddish; hypopygium dark. Male hypopygium (Plate 2, fig. 25) with the tergite, *9t*, transverse, the caudal margin deeply emarginate, the lateral lobes obtusely rounded. Basistyle, *b*, relatively small, the ventromesal lobe of moderate size. Dorsal dististyle strongly curved at near two-thirds the length. Ventral dististyle, *vd*, fleshy, larger than the basistyle; rostral prolongation long and stout, bearing a single long, very slender spine from an enlarged basal tubercle close to tip of prolongation; no trace of a second rostral spine. Gonapophyses, *g*, with the mesal-apical lobe long, obtuse at tip, bearing a slender erect spine at near midlength. Ædeagus, *a*, large, the apex distinctly bilobed.

Habitat.—Formosa.

Holotype, male, Shinten, near Taihoku, December 12, 1929 (*S. Issiki*).

The present fly is closest to *Limonia* (*Geranomyia*) *septemnotata* (Edwards), of Formosa, and *L.* (*G.*) *tenuispinosa* (Alexander), of eastern China. The former is still known only from the unique type female, taken in the high mountains; it differs in the coloration of the head and pleura, the pale brown legs, and the details of wing pattern, especially the coloration of the outer medial field. The latter fly has a somewhat similar male hypopygium but a very different wing pattern and venation. The single very slender spine of the rostral prolongation of the male hypopygium of the present species is very different from that of all other regional members of the subgenus, though suggested by *tenuispinosa*, where the second spine lies near the base of the prolongation and is small, tending to be reduced. The possibility exists that such a spine occurs in the present fly and is broken, but I can detect no trace of its former presence.

LIMONIA (GERANOMYIA) BALIANA sp. nov. Plate 1, fig. 2; Plate 2, fig. 26.

Allied and generally similar to *javanica;* general coloration of præscutum dark brown, almost covered by three light gray stripes, the median one split by a capillary brown median vitta; scutellum gray; halteres pale yellow; femora obscure yellow, the tips brownish black; wings whitish, with a dark brown, chiefly costal pattern; male hypopygium with the tergite deeply notched medially; ventral dististyle very large and fleshy, the rostral spines arising from a long and powerful common basal tubercle, the outer spine from a smaller, slenderer tubercle.

Male.—Length, excluding rostrum, about 7 millimeters; wing, 7.2; rostrum, about 2.

Rostrum relatively short and stout, black, the surface with short erect setulæ. Antennæ black throughout; basal flagellar segments short-cylindrical, the outer more elongate, suboval; terminal segment subequal to penultimate. Anterior vertex light gray, the posterior vertex brownish black, divided medially by a narrow gray line extended backward from the anterior vertex.

Ground color of præscutum dark brown almost covered by three light gray stripes, the median one split by a capillary median brown vitta that ends at the suture; lateral interspaces reduced to narrow lines; scutum gray, the mesal edge of each lobe with a dark brown line; scutellum gray; mediotergite gray, with a brown median triangle, the point directed caudad. Pleura more or less darkened dorsally, the sternopleurite and pleurotergite light gray. Halteres pale yellow. Legs with the coxæ and trochanters greenish yellow; femora obscure yellow, the tips brownish black; tibiæ and basitarsi yellowish brown, the tips narrowly dark brown; terminal tarsal segments black. Wings (Plate 1, fig. 2) with the ground color whitish, with a dark brown, chiefly costal pattern, that is arranged about as in *javanica;* pale interspaces more extensive than in the latter, the darkened area at midlength of cell Sc conspicuously narrowed in cell R; dark area at end of vein R_3 with a small pale central spot above the tip of vein; no darkening in cell R_5 beyond cord; veins brown, somewhat darker in the infuscated areas. Venation: Sc_2 ending distinctly beyond midlength of the angulated and weakly spurred Rs; m-cu at fork of M.

Abdominal tergites dark brown, the caudal borders of the intermediate segments somewhat paler. Male hypopygium (Plate 2, fig. 26) with the tergite, 9*t*, deeply notched medially, the rounded lobes with numerous setæ of moderate length. Basistyle, *b*, small. Ventral dististyle, *vd*, very large and fleshy, its area several times that of the basistyle; rostral prolongation small, with a conspicuous armature, consisting of a long fused basal tubercle bearing two powerful curved spines, the outermost of which arises from a further swollen basal portion; under high magnification, each of these spines has a median split throughout the length, being apparently formed from the fusion of two slenderer spines. Dorsal dististyle small, sickle-shaped, subequal to the rostral spines. Gonapophyses, *g*, with the mesal-apical blade flattened, its margin with microscopic denticles. Ædeagus, *a*, with numerous delicate setulæ on either side back from tip.

Habitat.—Bali.

Holotype, male, July 1–2, 1929 (*I. M. Mackerras*).

Limonia (*Geranomyia*) *baliana* is closest to *L.* (*G.*) *javanica* (Alexander), of western Java, differing chiefly in the colorational details, as the yellow halteres and the conspicuous whitish ground color of the wings. The male sex of *javanica* is still unknown and the hypopygium will very probably yield other characters, since it belongs to a group that shows great diversity in hypopygial details. The general type of hypopygium of the present fly, with two rostral spines arising from a long common basal tubercle, is found in several other Oriental and eastern Palæarctic species of the subgenus, as *L.* (*G.*) *apicifasciata* (Alexander), *L.* (*G.*) *immobilis* (Alexander), *L.* (*G.*) *multipuncta* (Alexander), *L.* (*G.*) *phœnosoma* (Alexander), and others, but all details are quite distinct.

LIMONIA (GERANOMYIA) JAVANICA KOCKENSIS subsp. nov.

Characters as in typical *javanica* Alexander (western Java), differing in colorational details, especially the gray sternopleurite and sternum and the black legs.

Posterior vertex blackened, with a median gray line that is a caudal extension of the narrow anterior vertex. Pleura entirely gray, the dorsal sclerites darker. Halteres yellow, the knobs dark brown. Legs beyond the trochanters black, only the femoral bases very narrowly and restrictedly paler. Abdominal sternites obscure yellow.

Habitat.—Sumatra.

Holotype, female, Fort de Kock, altitude 3,000 feet, 1925 (*E. Jacobson*). Paratopotype, female.

LIMONIA (GERANOMYIA) VANIKORENSIS sp. nov. Plate 1, fig. 3.

General coloration of mesonotal præscutum chestnut brown, paler laterally; rostrum, palpi, and antennæ black, legs dark brown to black; wings grayish subhyaline, with about six small costal and subcostal darkenings, the last two at ends of veins R_3 and R_{4+5}; Rs angulated near origin.

Female.—Length, excluding rostrum, about 6.5 millimeters; wings, 7.2; rostrum, about 3.2.

Rostrum elongate, black throughout; palpi 1-segmented. Antennæ black throughout; flagellar segments subcylindrical, not or scarcely decreasing in length outwardly, the last elongate. Head black, the narrow anterior vertex light gray, the color continued back onto the mid-region of posterior vertex as a narrow line.

Pronotum brownish black, paler laterally. Mesonotal præscutum deep chestnut brown on disk, the humeral and lateral portions more yellowish; scutal lobes dark brown, the median region and scutellum more testaceous; mediotergite reddish testaceous. Pleura chiefly reddish brown. Halteres pale, the knobs infuscated. Legs with the coxæ and trochanters reddish testaceous; remainder of legs dark brown to black, the femoral bases a little paler. Wings (Plate 1, fig. 3) grayish subhyaline, with about six small costal and subcostal darkenings, the first at the supernumerary crossvein in cell Sc, the second at origin of Rs, third at fork of Sc; fourth, paler, the small subcircular stigma; last two areas at ends of veins R_3 and R_{4+5}; cord and outer end of cell 1st M_2 narrowly seamed with paler brown; veins brown, somewhat darker in the clouded areas. Venation: A weak supernumerary crossvein in cell Sc; vein Sc relatively long, Sc_1 ending shortly before fork of Rs, Sc_2 at its tip; free tip of Sc_2 and R_2 about in transverse alignment; Rs from about two and one-half to nearly three times as long as the basal section of R_{4+5}, markedly angulate near origin; m-cu shortly beyond fork of M.

Abdomen chiefly dark brown, the genital region more yellowish. Ovipositor with cerci moderately long, nearly straight, the tips broadly and obtusely rounded.

Habitat.—Santa Cruz Islands.

Holotype, female, Vanikoro Island (*C. M. Deland*). Received through Mr. Frank H. Taylor, to whom the type has been returned.

The only other member of the subgenus from the smaller and more-remote Pacific Islands is *Limonia* (*Geranomyia*) *samoana* (Edwards), of Samoa, which is the species most generally similar to the present fly. It differs in the details of body coloration, wing pattern, and venation. *Limonia* (*G.*) *sagittifer* (Alexander), of North Queensland, is also somewhat closely allied to both of the above, yet evidently distinct by the coloration of the body and wings and in the venational details.

LIMONIA (PSEUDOGLOCHINA) BRYOPHILA sp. nov. Plate 1, fig. 4; Plate 2, fig. 27.

Mesonotum dark brown, the cephalic and lateral portions of præscutum abruptly yellowish white; a narrow pale median vitta extends from the præscutum to base of abdomen; pleura yellowish white, the sternopleurite and fore coxæ dark brown; tibiæ with two narrow dark rings, widely separated; wings with a strong brown tinge, the costal region still darker; Sc_1 ending opposite or before midlength of Rs; medial forks short; vein 2d A relatively long and extended.

Male.—Length, about 5.5 millimeters; wing, 6.

Female.—Length, about 5.5 to 6 millimeters; wing, 6 to 6.5.

Rostrum brown; palpi brownish black. Antennæ brownish black throughout, nodulose, the individual flagellar segments oval, with short but distinct necks. Head pale yellowish brown.

Pronotum pale yellow. Mesonotum chiefly dark brown, the projecting præscutum abruptly pale yellowish white on front and sides; a narrow capillary pale line begins on the præscutum, extending caudad to abdomen, widest on the scutellum and base of mediotergite. Pleura almost entirely yellowish white, contrasting abruptly with the mesonotum; ventral sternopleurite dark brown. Halteres dark brown. Legs with the fore coxæ and trochanters dark brown, the remaining coxæ and trochanters pale yellow; forelegs broken; mid-femora dirty white, becoming clearer on outer third, the tip very narrowly darkened; posterior femora white, the distal fifth abruptly blackened; tibiæ pure white, with two very narrow, subequal, brownish black rings, the distance between them about equal to six or seven times the width of either ring; tarsi white. Wings (Plate 1, fig. 4) with a strong brown tinge, the costal region more saturated; stigma oval, dark brown; a small brown cloud at origin of Rs; veins brown. Venation: Sc ending opposite or just before midlength of Rs; Rs and basal section of R_{4+5} only slightly oblique in position; medial forks short; m-cu variable in position, in cases about one-half its length before fork of M; vein 2d A relatively long and extended.

Abdominal tergites dark brown, the sternites pale yellow; outer sternites more or less darkened basally. Male hypopygium (Plate 2, fig. 27) with the tergite, *9t*, shallowly notched. Dorsal dististyle pale yellow. Ventral dististyle, *vd*, large and fleshy, much exceeding the basistyle in size, the rostral prolongation with a single pale spine. Gonapophyses, *g*, with mesal-apical lobe stout.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, on mossy cliffs in river gorge, altitude 3,600 feet, July 27, 1932 (*Franck*). Allotopotype, female. Paratopotype, female.

The closest ally of the present fly is *Limonia* (*Pseudoglochina*) *riukiuensis* Alexander (Japan: Riukiu Islands), which differs in the more oblique anterior cord, deeper medial forks, and more elongate and extended vein 2d A. The macrotrichia of the wing veins in *riukiuensis* are longer and more abundant, including nearly the outer half of M and the outer end of the basal section of Cu_1. The present fly was associated on mossy cliffs with specimens of the superficially rather similar *Limonia* (*Limonia*) *unicinctifera* Alexander.

ORIMARGA (ORIMARGA) NUDIVENA sp. nov. Plate 1, fig. 5; Plate 2, fig. 28.

General coloration dark grayish brown, the ventral surfaces of thorax and abdomen reddish; antennæ black; wings broad; costal fringe (male) long and conspicuous; macrotrichia of veins very sparse, lacking on R_3; R_{1+2} about twice R_2, the latter subequal to R_{2+3}; vein 2d A elongate; male hypopygium with the armature of the phallosome conspicuously developed as spinous points.

Male.—Length, about 4.5 millimeters; wing, 5.

Rostrum reddish brown. Antennæ black throughout; flagellar segments short-oval. Head dark gray.

Mesonotum grayish brown, the præscutum indistinctly striped. Pleura reddish brown. Halteres brown. Legs with coxæ and trochanters reddish; remainder of legs black. Wings (Plate 1, fig. 5) broad, widest opposite level of outer end of cell 1st A; color grayish, veins pale brown. Costal fringe very long and erect; macrotrichia of veins very sparse, with a scattered series on vein R, distal section of R_5 and outer end of M_{1+2}; no trichia on vein R_3. Venation: R_{1+2} about twice R_2, the latter subequal to R_{2+3}; basal section of R_{4+5} angulated at origin; vein 2d A elongate, ending opposite level of m-cu.

Abdominal tergites dark brown, the sternites reddish. Male hypopygium (Plate 2, fig. 28) with the armature of the phallosome, *p*, well-developed and conspicuous.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, altitude 3,000 feet, July 8, 1932 (*Franck*).

Orimarga (*Orimarga*) *nudivena* is well-distinguished from all regional allies by the unusual glabrousness of the wing veins and the conspicuous development of the phallosomic region of the male hypopygium.

ORIMARGA (ORIMARGA) ÆQUIVENA sp. nov. Plate 1, fig. 6.

General coloration of body blackish gray; wings with a grayish tinge; costal fringe of moderate length in both sexes; macrotrichia of veins numerous, including a complete series on vein R_3; R_{2+3} and R_2 subequal.

Male.—Length, about 4.5 millimeters; wing, 4.

Female.—Length, about 5 millimeters; wing, 4.6.

Rostrum and palpi black. Antennæ black throughout; flagellar segments oval. Head dark gray.

Thorax dark blackish gray, the præscutum without stripes. Halteres pale, the knobs blackish. Legs with the fore coxæ brownish black, the remaining coxæ somewhat paler; trochanters pale brown; femora light yellowish brown, the tips dark brown; tibiæ and tarsi pale brown, the outer tarsal segments blackened. The legs are more uniformly blackened in the female. Wings (Plate 1, fig. 6) with a grayish tinge, darker in the female; veins brown. Costal fringe of moderate length only; macrotrichia of veins short but numerous, including complete series on veins R_3, R_{4+5}, M_3, M_4, and all of M_{1+2} except the base. Venation: Sc_1 ending opposite two-thirds Rs, Sc_2 near its tip; R_{2+3} subequal to R_2, the latter a little longer than R_{1+2}; free tip of Sc_2 pale but evident, R_1 subequal to R_{1+2}; forks of medial cells of moderate depth; m-cu opposite basal fourth or fifth of Rs. In the female, R_{1+2} is longer, being nearly twice R_2 alone; medial forks deeper.

Abdomen brownish black, the sternites a trifle brighter.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, altitude 4,200 feet, July 5, 1932 (*Franck*). Allotype, female, altitude 4,800 feet, July 4, 1932 (*Franck*). Paratypes, altitude 4,200 feet, June 29 to July 5, 1932; altitude 4,800 feet, July 4, 1932.

Of the species of *Orimarga* so far discovered in western China, the only species with a somewhat similar venation is *O.* (*O.*) *cruciformis* Alexander, which is readily told by the unusually long narrow wings, with long basal petiole and with a cruciform arrangement of veins at end of Rs. The Formosan species *O.* (*O.*) *fuscivenosa* Alexander and *O.* (*O.*) *taiwanensis* Alexander have a somewhat similar arrangement of veins in the radial field, but are distinguishable by the shape of the wing and the venation, *fuscivenosa* having the wings unusually narrow, cell

M_3 deeper, and cell 2d A narrower; *taiwanensis* differs in the yellowish wings, with pale veins, and in the slightly different venational details.

PEDICIINI

PEDICIA (NASITERNELLA) HOKKAIDENSIS sp. nov. Plate 1, fig. 7; Plate 2, fig. 29.

Allied to *hyperborea;* mesonotal præscutum yellowish gray, with four dark brown stripes; legs with femora obscure yellow to brownish yellow, the tips narrowly dark brown; wings yellowish, heavily patterned with brown; costal darkenings between Sc_2 and origin of Rs widely separated, between Rs and tip of Sc_1 narrowly separated; male hypopygium with setæ at end of arm of basistyle relatively short and inconspicuous; interbase with outer end suddenly narrowed.

Male.—Length, about 11 to 12 millimeters; wing, 11 to 11.5.

Rostrum and palpi dark brown. Antennæ broken. Head dark gray.

Mesonotal præscutum yellowish gray, with four dark brown stripes, the intermediate pair only narrowly separated, confluent at anterior ends, the posterior ends not reaching the suture; scutal lobes variegated with dark brown; scutellum dark brown, obscure yellow beneath; mediotergite dark brownish gray. Pleura brownish gray. Halteres broken. Legs with coxæ pale, darker basally, more extensively so on posterior legs; trochanters yellow; femora obscure yellow to brownish yellow, the tips narrowly dark brown; tibiæ pale brown, the tips very narrowly dark brown; tarsi pale brown, the outer segments darker. Wings (Plate 1, fig. 7) with the ground color strongly yellowish, heavily patterned with brown, chiefly as large marginal clouds at ends of all longitudinal veins; areas at Sc_2 and origin of Rs widely separated, the pale area between fully as wide as either dark area; pale costal area between origin of Rs and tip of Sc_1 reduced in size. Venation: Rs relatively short, angulated at origin; m present (in types).

Abdomen dark brown. Male hypopygium (Plate 2, fig. 29) much as in *hyperborea;* setæ at apex of the long slender arm of basistyle, *b,* short and inconspicuous. Interbase, *i,* broad basally, the outer half or less suddenly narrowed.

Habitat.—Japan (Hokkaido).

Holotype, a broken male Sôunkyô, June 4, 1932 (*S. Issiki*). Paratopotype, a broken male.

Pedicia (*Nasiternella*) *hokkaidensis* is allied to but obviously distinct from the Nearctic *P.* (*N.*) *hyperborea* (Osten Sacken), differing in the characters listed above. I am not in possession of a specimen of *P.* (*N.*) *variinervis* (Zetterstedt), type of the subgenus, and know the species only from Wahlgren's notes and figures of the Zetterstedt types.[4] There are a few important distinctions shown in the figures that apparently do not enter into the general plasticity of venation of the species; that is, the arcuate Rs, long and conspicuous basal section of R_{4+5}, and proportionately short second section of the latter vein. In the light of the evident distinctness of *hyperborea*, I believe the male hypopygium of the present species and *variinervis* will likewise show differences when the latter becomes available for comparison. In 1933, it was first detected that *hyperborea* had a subapterous female and it seems certain that the two Palæarctic species above discussed will be found likewise to agree in this respect.

DICRANOTA (RHAPHIDOLABIS) PLATYMERA sp. nov. Plate 1, fig. 8; Plate 2, fig. 30.

General coloration gray, the præscutum with three darker grayish brown stripes; antennæ 12-segmented, black throughout; legs pale, the femoral tips darker; wings milky white, the stigma scarcely indicated; cell R_3 sessile; abdomen brown, the hypopygium a little brighter; male hypopygium with the lateral tergal arms appearing as acute spines, the median area convex; interbase flattened, the apex an acute spine.

Male.—Length, about 4.5 to 5 millimeters; wing, 6 to 6.5.

Rostrum and palpi brown. Antennæ black throughout, 12-segmented; flagellar segments oval, the terminal segment more elongate. Head dark gray.

Mesonotum gray, the præscutum with three darker grayish brown stripes. Pleura chiefly pale. Halteres pale, the knobs weakly darkened. Legs with the coxæ and trochanters pale; femora yellow, the tips passing into pale brown; tibiæ and tarsi pale yellowish brown, the terminal segments of the latter darkened. Wings (Plate 1, fig. 8) milky white; stigma not or scarcely indicated; veins pale brown. Venation: Rs arcuated; cell R_3 sessile; R_{1+2} short to punctiform; cell M_2 open.

Abdomen dark brown, the hypopygium brighter. Male hypopygium (Plate 2, fig. 30) with the median region of tergite, *9t*, broadly convex; lateral arms appearing as acute simple spines. Interbasal process, *i*, flattened, the outer margin microscopically serrulate, the apex directed laterad into an acute spine.

---

[4] Arkiv för Zoologi 2 No. 7 (1904) 4, figs. 1–3.

Apices of basistyle, *b*, and outer dististyle, *od*, with microscopic spines.

Habitat.—Japan (Honshiu).

Holotype, male, Yumoto, Shimotsuke, altitude 4,850 feet, June 20, 1932 (*S. Issiki*). Paratopotype, a fragmentary male.

The only near regional ally so far described is *Dicranota* (*Rhaphidolabis*) *spina* Alexander (Honshiu, Hokkaido), which is well-distinguished by hypopygial characters, notably the shape of the interbasal process.

HEXATOMINI

PSEUDOLIMNOPHILA MOBILIS sp. nov. Plate 1, fig. 9; Plate 2, fig. 31.

General coloration of thorax dark gray, the dorsopleural region buffy; middle and posterior coxæ chiefly pale; posterior femora obscure yellow, the tips narrowly darkened; wings tinged with yellow; small, pale brown clouds at origin of Rs, along cord, outer end of cell 1st M_2, and in axillary region; R_2 lacking or very poorly indicated; abdomen dark brown, the caudal borders of the intermediate segments pale.

Male.—Length, about 8 millimeters; wing, 8.

Rostrum gray; palpi black. Antennæ brownish black throughout; flagellar segments long-oval. Head light gray.

Thorax dark, blackish gray, the præscutum without stripes; dorsopleural region more buffy. Halteres pale yellow. Legs with the fore coxæ darkened, the other coxæ chiefly pale; trochanters yellow; femora obscure yellow, the tips narrowly darkened (only posterior legs remaining); tibiæ light brown, the tips narrowly blackened; tarsi black. Wings (Plate 1, fig. 9) tinged with yellow, the prearcular and costal regions clearer yellow; stigma elongate-oval, brown; small and ill-delimited pale brown clouds at origin of Rs, cord and outer end of cell 1st M_2; axillary region narrowly darkened; veins brown, the prearcular field light yellow. Venation: Both Sc_1 and Sc_2 ending before level of fork of Rs; R_2 lacking or so faintly indicated as to be scarcely visible, approximately in the position indicated in figure; region of stigma with no interruption of the microtrichia in this field; m-cu at midlength of cell 1st M_2.

Abdomen dark brown, the caudal borders of the intermediate segments narrowly pale; ninth segment dark. Male hypopygium (Plate 2, fig. 31) with the notch of the tergite, *9t*, relatively shallow. Basistyle, *b*, simple. Outer dististyle, *od*, with the apical spine moderately blackened. Interbase, *i*, bispinous, as figured.

Habitat.—Japan (Hokkaido).

Holotype, male, Sôunkyô, June 4, 1932 (*S. Issiki*).

Pseudolimnophila mobilis is most closely allied to *P. horii* Alexander in the dark gray color of the thorax and general coloration of the wings. The slightly patterned wings, with the details of venation distinct, together with the structure of the hypopygium, especially the basistyle and interbase, should readily separate the present fly from other similar species.

PSEUDOLIMNOPHILA YUMOTANA sp. nov. Plate 1, fig. 10; Plate 2, fig. 32.

Male.—Length, about 8 millimeters; wing, 9.5.

Closely allied to *Pseudolimnophila horii* Alexander, differing especially in the conspicuously patterned wings and slight differences in the male hypopygium.

Mesonotum gray, the præscutum with three nearly confluent dark brown stripes. Pleura dark gray. Wings (Plate 1, fig. 10) with a grayish yellow tinge, patterned with brown, including the stigma, seams at origin of Rs, cord, outer end of cell 1st M_2, Cu, and in axillary region, the cubital darkening being especially conspicuous. Venation: Sc_1 ending opposite fork of Rs Sc_2 at its tip; R_2 slightly longer than R_{1+2}; distinct; R_3 strongly sinuous; m-cu erect, just beyond midlength of cell 1st M_2.

Male hypopygium (Plate 2, fig. 32) with the notch of the tergite, *9t*, U-shaped, unusually deep. Basistyle, *b*, with a triangular protuberance on mesal face near apex. Interbase, *i*, with the two spines lying parallel, the outer a little longer.

Habitat.—Japan (Honshiu).

Holotype, male, Yumoto, Shimotsuke, altitude 4,850 feet, June 20, 1932 (*S. Issiki*).

Pseudolimnophila horii has the wings unpatterned excepting for the stigma and a more or less evident darkening on the anterior cord.

PSEUDOLIMNOPHILA ERECTA sp. nov. Plate 1, fig. 11.

General coloration gray, the præscutum with four darker brownish gray stripes, the intermediate pair separated by a narrow line of the ground color; wings strongly tinged with yellow, sparsely patterned with brown; Sc short, Sc_1 ending before fork of Rs; R_{2+3+4} short and suberect, subequal in length to m-cu.

Female.—Length, about 8 to 9 millimeters; wing, 8 to 9.

Rostrum gray; palpi black. Antennæ black; flagellar segments elongate, fusiform. Head dark gray.

Mesonotum dark gray, with four narrow darker brownish gray stripes, the intermediate pair separated by a line of the ground color about equal in width to the stripes themselves. Pleura gray, the dorsopleural region chiefly darkened. Halteres yellow. Legs with the coxæ entirely clear gray (holotype) or with the tips yellow, on posterior legs including most of coxæ (paratype); trochanters yellow; femora and tibiæ obscure yellow, the tips passing into dark brown; tarsi light brown, the outer segments darker. Wings (Plate 1, fig. 11) strongly tinged with yellow, especially in the type, the prearcular and costal regions more conspicuously luteous; stigma and a cloud on anterior cord darkened; in holotype, a dark cloud at origin of Rs; in paratype, vein Cu evidently seamed with pale brown; veins pale, more yellowish in the luteous areas. Venation: Sc short, Sc_1 ending before fork of Rs, Sc_2 at its tip; R_2 and R_{1+2} distinct and subequal in length; R_{2+3+4} unusually short and suberect in position, subequal to m-cu; R_3 not conspicuously arched on basal half; basal section of R_{4+5} short to very short; petiole of cell M_1 subequal to or a little longer than m-cu, the latter at near two-thirds the length of cell 1st M_2.

Abdomen dark brown; shield of ovipositor brownish black; valves horn yellow, cerci relatively short.

Habitat.—Japan (Honshiu).

Holotype, female, Lake Chuzenji (Tzujenji), Shimotsuke, altitude 4,100 feet, June 22, 1932 (*S. Issiki*). Paratype, female, Konseitoge, Shimotsuke, altitude 5,200 to 6,500 feet, June 21, 1932 (*S. Issiki*).

In the gray coloration of the thorax, *Pseudolimnophila erecta* is most generally similar to *P. horii* Alexander and *P. yumotana* sp. nov., being separated by the presence of four præscutal stripes and by the venation, especially the short, elevated R_{2+3+4}.

LIMNOPHILA (PRIONOLABIS) SOUNKYANA sp. nov. Plate 1, fig. 12; Plate 2, fig. 33.

General coloration black, the thorax subopaque to opaque by a gray pruinosity; male hypopygium with the notch of tergite evenly and shallowly rounded; both dististyles short, the inner only a little less than the outer.

Male.—Length, about 9 to 9.5 millimeters; wing, 10.5 to 11.

Female.—Length, about 9 millimeters; wing, 8.5 to 9.

Rostrum, palpi, and antennæ black, the latter 16-segmented in both sexes; basal segments with outer faces protuberant; outer segments passing into oval. Head dull black, sparsely gray pruinose.

Mesonotum black, the surface subopaque by a sparse pruinosity. Pleura somewhat more heavily pruinose. Halteres pale yellow. Legs with the coxæ and trochanters black; femora yellow, the tips blackened, most extensively so on forelegs where the outer three-fourths is included, more narrowly on the posterior legs where the outer fourth is darkened. Wings (Plate 1, fig. 12) with the stigma small and relatively inconspicuous; dark seams of wing extensive but pale and diffuse; venation of medial field variable, especially of cells near the cord.

Abdomen, including hypopygium, black. Male hypopygium (Plate 2, fig. 33) with the notch of tergite, 9*t*, evenly rounded. Both dististyles (*od, id*) small and heavily blackened, the outer only a little longer than the inner.

Habitat.—Japan (Hokkaido).

Holotype, male, Sôunkyô, June 4, 1932 (*S. Issiki*). Allotopotype, female. Paratopotypes, 1 male, 1 female.

Limnophila (*Prionolabis*) *sôunkyana* is most closely allied to *L.* (*P.*) *neomunda* Alexander, likewise from Hokkaido, differing in the much larger size and details of structure of the hypopygium, especially of the dististyles. Of the fourteen Japanese and Formosan species of *Prionolabis* so far discovered, these two are most similar in the structure of the male hypopygium, but certainly appear to represent entirely distinct species.

LIMNOPHILA (PRIONOLABIS) LUTEIBASALIS sp. nov. Plate 1, fig. 13; Plate 3, fig. 34.

General coloration polished black; antennæ 13-segmented in both sexes; wings (female) reduced, light yellow on basal third, the remainder darker; wings (male) fully developed; cells R_3 and M_1 present; male hypopygium with caudal margin of tergite weakly trilobed.

Male.—Length, about 8 millimeters; wing, 9.

Female.—Length, about 7 millimeters; wing, 2.

Female.—Rostrum and palpi black. Antennæ black throughout, 13-segmented; flagellar segments oval, with verticils that exceed the segments; terminal segment elongate and evidently a fusion of segments, about one-half longer than the eighth flagellar segment; penultimate segment not clearly cut off from terminal segment, smaller than the antepenultimate. Head black, very sparsely pruinose; anterior vertex wide, the eyes correspondingly small.

Thoracic dorsum black, polished; pleura somewhat more pruinose. Halteres small, not exceeding one-half the length of wings, dusky at base, the knobs clear yellow. Legs stout and hairy, brownish yellow, the femoral tips broadly blackened, somewhat more extensively so on forelegs; tibiæ yellowish brown, the tips darker; tarsi black. Wings reduced, stenopterous; basal third clear light yellow, the remainder suffused with dark brown, chiefly produced by the veins and adjoining membrane. Macrotrichia present on veins C and R, and as sparse groups on veins beyond cord. Venation distorted but showing Rs elongate; cell R_3 present and deep; cell M_1 present, small.

Abdomen black; ovipositor with valves unusually long and powerful, horn yellow, the cerci nearly straight with the tips gently upcurved.

Male.—Characters as in female, differing especially in the fully winged condition. Antennæ as in female, some of the intermediate segments showing traces of fusion. Halteres normally developed, pale, the knobs light yellow. Legs long and slender; fore femora with more than outer half blackened; hind femora with only the tips narrowly darkened. Wings (Plate 1, fig. 13) yellow, the prearcular and costal regions clearer yellow; stigma oval, brown; dark pattern on disk greatly reduced or lacking. Male hypopygium (Plate 3, fig. 34) with the central portion of tergite, 9*t*, produced, its margin weakly trilobed. Inner dististyle, *id*, with two long slender spines that are closely appressed to the apical point.

Habitat.—Japan (Honshiu).

Holotype, female, Konseitoge, Shimotsuke, altitude 5,200 to 6,500 feet, June 21, 1932 (*S. Issiki*). Allotopotype, female. Paratopotypes, 2 broken females.

The only other species with reduced wings in the female sex is *Limnophila* (*Prionolabis*) *imanishii* Alexander (Japanese Alps), which has antennæ of similar segmentation and structure. The present fly has the wings of the female proportionately longer, broader at base, and with the conspicuous coloration above described. In *imanishii* the wings are yellowish brown throughout. The male sex appears to be correctly associated with its female. The reduced number of antennal segments in both sexes readily separates the present fly from all allies, including *L.* (*P.*) *odai* Alexander, the male hypopygium of which has a very similar ninth tergite.

LIMNOPHILA (PRIONOLABIS) INERMIS sp. nov. Plate 1, fig. 14; Plate 3, fig. 35.

Belongs to the *lipophleps* group; general coloration black; male hypopygium with the outer dististyle simple; gonapophysis narrowed to an acute apical point, before tip on outer margin with a crest of about five or six small subappressed spinules; on inner margin at about three-fourths the length with a single long acute spine.

Male.—Length, about 4 millimeters; wing, 5.5.

Female.—Length, about 4.5 millimeters; wing, 5 to 5.5.

Rostrum and palpi black. Antennæ black throughout; flagellar segments short-oval. Head black.

Pronotum and mesonotum black, the surface subnitidous. Pleura black, subopaque. Halteres broken. Legs with coxæ and trochanters black; remainder of legs brownish black to black, the femoral bases narrowly obscure yellow, a trifle more extensive on the posterior legs; legs relatively long and slender in both sexes. Wings (Plate 1, fig. 14) with a faint brown tinge; stigma oval, pale brown; veins pale brown. Venation: Cell M_1 lacking, as in the group; m-cu about one-half its length beyond fork of M.

Abdomen, including hypopygium, black. Male hypopygium (Plate 3, fig. 35) with the outer dististyle, *od*, simple, gradually narrowed to an acute, gently curved black point; inner dististyle narrowed into a long slender apical point. Gonapophyses, *g*, as figured.

Habitat.—Japan (Honshiu).

Holotype, male, Lake Chuzenji (Tzujenji), Shimotsuke, altitude 4,100 feet, June 22, 1932 (*S. Issiki*). Allotopotype, female. Paratopotypes, 2 broken females.

Limnophila (*Prionolabis*) *inermis* is allied to the three other members of the *lipophleps* group occurring in the Japanese Empire, differing decisively in the structure of the male hypopygium, especially the unarmed outer dististyle and the conformation of the gonapophyses.

LIMNOPHILA (TRICHOLIMNOPHILA) PRIONOLABOIDES sp. nov. Plate 1, fig. 15; Plate 3, fig. 36.

General coloration of thorax gray, the præscutum with three polished black stripes; fore femora with outer half blackened; abdomen, including hypopygium, black; male hypopygium with median notch of tergite relatively narrow, the lateral lobes broad, more or less bilobed by the presence of a lateral flange.

Male.—Length, 6 to 6.5 millimeters; wing, 7 to 8.

Female.—Length, about 7.5 millimeters; wing, 8.5.

Rostrum and palpi black. Antennæ (male) relatively long, if bent backward extending to mid-distance between the roots of the halteres and wings; scape brownish black; pedicel and flagellum brown, the outer flagellar segments passing into dark brown. Head light gray.

Pronotum dark gray. Mesonotal præscutum brownish gray, the usual three stripes highly polished, black, including the entire area of the stripe, not merely the cephalic portion, as in *pilifer;* scutum opaque brownish gray; scutellum clearer gray; mediotergite gray. Pleura dark gray. Halteres pale yellow. Legs with the fore coxæ darkened, the remaining coxæ yellow, a little infuscated at bases; trochanters yellow; femora yellow, the tips broadly blackened, most extensively so on the forelegs where fully the outer half is included; on middle and hind legs including about the outer fifth or sixth; tibiæ obscure yellow, the tips narrowly brownish black; basitarsi pale brown, the outer half and remainder of tarsi black. Wings (Plate 1, fig. 15) brownish yellow, the prearcular region clear light yellow; a restricted brown pattern, distributed as follows: Stigma, origin of Rs, cord, and outer end of cell 1st M_2; veins brown, yellow in the luteous prearcular region. Macrotrichia in outer ends of cells R_2 to M_4, inclusive. Venation: m-cu at or before mid-length of cell 1st M_2.

Abdominal tergites brownish black; sternites somewhat paler brown; hypopygium black. Male hypopygium (Plate 3, fig. 36) with the median region of tergite, 9*t*, somewhat produced, the lobes broad, each with a conspicuous lateral shoulder or flange; median notch relatively deep and narrow, the caudal end a little narrowed.

Habitat.—Japan (Honshiu).

Holotype, male, Yumoto, Shimotsuke, altitude 4,850 feet, June 20, 1932 (*S. Issiki*). Allotopotype, female. Paratopotypes, 3 males.

The nearest ally is undoubtedly *Limnophila* (*Tricholimnophila*) *pilifer* Alexander, which has the præscutal stripes pruinose excepting the cephalic ends of the intermediate pair, which are polished black. The latter species differs further in the reddish brown hypopygium, narrowly darkened fore femora, and the details of the hypopygium, as the very broad and relatively shallow tergal notch. The polished black præscutal stripes of the present fly produce a marked superficial resemblance to certain small species of the subgenus *Prionolabis*, as *L.* (*P.*) *odai* Alexander.

ELEPHANTOMYIA (ELEPHANTOMYODES) MACKERRASI sp. nov. Plate 1, fig. 16.

Size large (wing, male, over 10 millimeters); mesothorax orange-yellow, immaculate; head brownish yellow; tarsi extensively snowy white; wings with a faint brown tinge; cells C and Sc dark brown; narrow but conspicuous brown seams at origin of Rs, along cord and outer end of cell 1st M_2; subterminal abdominal segments black.

Male.—Length, excluding rostrum, about 11 to 11.5 millimeters; wing, 10.8 to 11; rostrum, 6.5 to 6.7.

Rostrum black. Antennæ black, the basal portion of scape paler. Head obscure brownish yellow; anterior vertex at narrowest point about one-half wider than scape.

Mesonotum and pleura yellow or orange-yellow, immaculate. Halteres pale, the knobs dark brown. Legs with the coxæ yellow; trochanters yellowish testaceous; femora black, the bases restrictedly obscure yellow; tibiæ black; basitarsi black, the tips narrowly snowy white; segments two and three white, the remaining tarsal segments black. Wings (Plate 1, fig. 16) with a faint brownish tinge, patterned with dark brown, including all of cells C and Sc, stigma, and cell R_2 beyond it; relatively broad and conspicuous brown seams at origin and fork of Rs, along cord and outer end of cell 1st M_2; veins brownish black. Venation: Rs square at origin; m-cu nearly its own length beyond fork of M; cell 2d A of moderate length and width.

Basal abdominal tergites weakly bicolorous, obscure yellow basally, the outer one-half or more passing into dark brown; seventh and eighth segments uniformly blackened; hypopygium brownish black.

Habitat.—Java.

Holotype, male, Mount Malabar, altitude about 4,000 feet, May 26, 1929 (*I. M. Mackerras*). Paratopotype, male.

I take great pleasure in naming this conspicuous *Elephantomyia* after the collector, my friend Dr. Ian M. Mackerras. Compared with the thirteen other species of the subgenus *Elephantomyodes* described to date, the present fly is generally similar to *E.* (*E.*) *aurantia* (Brunetti), of British India, and *E.* (*E.*) *fuscomarginata* Enderlein, of Sumatra, by the combination of white tarsi and yellowish head. It differs from these and all other Malayan species with white tarsi in the conspicuously patterned wings. Members of the subgenus are now known from as far east as New Britain and on the Australian mainland to northern New South Wales.

ERIOPTERINI

Genus LECTERIA Osten Sacken

Lecteria OSTEN SACKEN, Berliner Ent. Zeitschr. 31 (1887) 206.

Subgenus NEOLECTERIA novum

Characters as in typical *Lecteria,* differing only in the lack of cell M_1 of the wings.

Type of subgenus.—*Lecteria bipunctata* Edwards (Oriental Region: Borneo).[5]

As hitherto constituted, *Lecteria* includes besides the genotype, *armillaris* (Fabricius), of the Neotropics, about fifteen African species that have been discussed by the writer in another report.[6] The Bornean fly differs from all other described members of the genus in the loss of cell M_1 of the wings, a character that appears to me to be of considerable importance in the hexatomoid Eriopterini.

Moreover, it is apparent that *Psaronius* Enderlein, with several species in the Neotropics, cannot be maintained as a genus separate from *Lecteria,* despite the presence of tibial spurs. All known species of *Psaronius* have cell M_1 present, as in typical *Lecteria.* These three subgeneric groups may be separated as follows:

1. Wings with cell M_1 present.
   Wings with cell M_1 lacking (Oriental) .... *Neolecteria* subgen. nov.
2. Tibial spurs present (Neotropical) .... *Psaronius* Enderlein.
   Tibial spurs lacking (Ethiopian, Neotropical) ...... *Lecteria* Osten Sacken.

GONOMYIA (GONOMYIA) OBSCURICLAVA sp. nov. Plate 1, fig. 17.

Belongs to the *cognatella* group; general coloration of notum dark brown; pleura light brown, with a broad ventral whitish stripe; rostrum black; halteres pale, the knobs infuscated; legs brownish black; wings with a strong brown tinge; stigma and a seam along cord brownish; m-cu shortly beyond fork of M; caudal margins of abdominal segments pale.

Female.—Length, about 3.5 millimeters; wings, 4.2.

Rostrum and palpi black. Antennæ with the scape reddish brown; pedicel blackish; first flagellar segment pale, remainder

---

[5] Sarawak Mus. Journ. 3 (1926) 265–266, pl. 9, fig. 10.

[6] Revue Zoologique Africaine 11 (1923) 375–381.

of flagellum black; antennæ (female) relatively long for a member of this genus; flagellar segments subcylindrical. Head with vertex pale.

Mesonotum dark brown, the anterior lateral pretergites white; posterior border of scutellum somewhat paler, obscure yellow. Pleura light brown, with a broad ventral whitish stripe, extending longitudinally from the fore coxæ to the base of the abdomen. Halteres pale, the knobs infuscated. Legs with the fore coxæ white, the remainder more yellowish testaceous; trochanters obscure yellow; remainder of legs brownish black. Wings (Plate 1, fig. 17) with a strong brown tinge, cells C and Sc somewhat clearer; stigma brown, oval, clearly defined; a distinct brownish suffusion along the cord; veins pale brown, darker along cord. Venation: Distance on costa between tips of R_{1+2} and R_3 equal to nearly two-thirds the total length of vein R_3; m-cu shortly beyond fork of M.

Abdomen dark brown, the caudal borders of the segments pale, a little more expanded at lateral angles of tergites.

Habitat.—Sumatra.

Holotype, female, Fort de Kock, altitude 3,000 feet, 1926 (*E. Jacobson*).

The only species of the *cognatella* group so far described from eastern Asia are *Gonomyia* (*Gonomyia*) *aperta* Brunetti (British India) and *G.* (*G.*) *subcognatella* Alexander (western China). The present fly differs most evidently in the combination of darkened knobs of halteres, the faint but distinct brown seam along cord of wings, the brownish black legs, and other characters.

GONOMYIA (LIPOPHLEPS) JACOBSONIANA sp. nov. Plate 1, fig. 18; Plate 3, fig. 37.

General coloration of thoracic notum dark brown, the posterior border of scutellum broadly pale yellow; pleura black, with a narrow white longitudinal stripe; femora brownish yellow, fore and middle femora with conspicuous black tips, posterior femora with a subterminal black ring; bases of all tibiæ narrowly blackened; veins almost uniformly grayish subhyaline; stigma very pale; Sc_1 ending immediately before origin of Rs; caudal borders of abdominal tergites (male) pale; male hypopygium with three dististyles, all simple.

Male.—Length, about 2.8 to 3 millimeters; wing, 3.5 to 3.7.

Female.—Length, about 3.5 to 4 millimeters; wing, 3.8 to 4.

Rostrum and palpi black. Antennæ black, the basal two segments restrictedly yellow beneath; flagellar verticils (male) very long. Head chiefly white, the center of the posterior vertex darkened.

Anterior lateral pretergites restrictedly china-white. Mesonotal præscutum almost uniformly dark brown; pseudosutural foveæ black, conspicuous; posterior sclerites of notum brownish black, the posterior border of scutellum broadly pale yellow; mediotergite more or less pruinose. Pleura black, with a narrow white longitudinal line from base of fore coxæ across dorsal sternopleurite and dorsal meral region to base of abdomen; pteropleurite and cephalic portion of pleurotergite much paler, more orange-yellow. Halteres pale, the knobs dark brown, narrowly lined with whitish. Legs with the coxæ chiefly dark, excepting the fore coxæ, as described; trochanters obscure yellow; femora brownish yellow; fore and middle femora with broad and conspicuous apical black rings, the posterior femora with nearly as wide but distinctly subterminal rings; all tibiæ brownish yellow, the bases narrowly, the tips somewhat more broadly blackened; basitarsi brown basally, the tips and remaining tarsal segments black. Wings (Plate 1, fig. 18) relatively broad, almost uniformly grayish subhyaline; stigma very pale and scarcely indicated; costal region not variegated; veins pale brown, a little darker along cord. Venation: Sc_1 ending just before origin of Rs, Sc_2 at tip; basal section of R_5 elongate, about one-half r-m; m-cu shortly before fork of M.

Abdomen dark brown, in male the caudal borders of the tergites conspicuously china-white; sternites more uniformly darkened, paler medially but without pale apical bands; hypopygium yellowish brown. In female, tergites more uniformly darkened or with the pale caudal borders restricted. Male hypopygium (Plate 3, fig. 37) with three dististyles, all simple rods; innermost style, *id*, jointed at base and here with a group of four or five strong setæ, at near three-fourths the length of style with a further group of about four conspicuous setæ; intermediate style unusually slender but nearly equal in length to the outer; outer style, *od*, broad basally, the inner margin of outer third with a flange.

Habitat.—Sumatra, Mindanao.

Holotype, male, Fort de Kock, Sumatra, altitude 3,000 feet, 1926 (*E. Jacobson*). Allotopotype, female. Paratopotypes, 8 of both sexes; paratypes, several of both sexes, Madaum River, Tagum, Davao district, Mindanao, at trap lantern, March 26 to 27, 1931 (*C. F. Clagg*).

I take unusual pleasure in naming this interesting *Gonomyia* after my old friend Mr. Edward Jacobson, distinguished student of the animal life of the Dutch East Indian islands. By Edwards's key to the Malayan species of *Lipophleps*[7] the present fly runs to *Gonomyia* (*Lipophleps*) *diffusa* (de Meijere), a species that is quite distinct in the pale brown subterminal rings on femora and the somewhat patterned, slightly infumed wings. I have not yet seen a male that can be definitely assigned to *diffusa,* which was described only from females. The present fly is amply distinct from all species of the subgenus so far described from Formosa and the Philippines.

GONOMYIA (LIPOPHLEPS) ACUSPINOSA sp. nov. Plate 3, fig. 38.

Male.—Length, about 3 millimeters; wing, 3.5.

Generally similar and closely allied to *G.* (*L.*) *jacobsoniana* sp. nov., differing in slight details of coloration and notable differences in the structure of the male hypopygium.

Antennæ dark throughout. Femora darker, the blackened tips on all legs terminal, preceded by a narrow, clearer yellow ring. Abdominal tergites uniformly darkened. Male hypopygium (Plate 3, fig. 38) with three dististyles; inner style, *id,* shortest, terminating in two acute spines, the outermost from a long basal tubercle that extends about to the level of the tip of inner spine, the actual spine short; inner spine long and slender, appressed to the outer one; mesal face of style at base, with a group of about nine or ten setæ surrounding a larger, more fasciculate one. Intermediate style, *md,* subequal in length to the outer, with almost the entire inner edge provided with a dense fringe of coarse appressed setulæ, these more protuberant and evident near base and at apex of style. Outer style, *od,* a simple, gently arcuated rod, shaped more or less like a slender boomerang. Phallosome, *p,* with the divergent arms terminating in acute blackened points, before tip a little expanded and microscopically setulose.

Habitat.—Sumatra.

Holotype, male, Fort de Kock, altitude 3,000 feet, 1926 (*E. Jacobson*).

A third species of the group is *Gonomyia* (*Lipophleps*) *alboannulata* Alexander (Philippines), which differs from the present fly in the structure of the two inner styles of the male hypopygium, the innermost being trispinous, the middle style with the setulæ confined to the somewhat enlarged distal half or less.

---

[7] Journ. Fed. Malay States Mus. 14 (1928) 104–105.

ERIOPTERA (TELENEURA) PERORNATA sp. nov. Plate 1, fig. 19; Plate 3, fig. 39.

General coloration of head, pronotum, and mesonotum pale brownish yellow, the thoracic pleura chiefly darkened; legs yellow, the femora with vague indications of a narrow, slightly darker subterminal ring; wings yellowish cream color, with a heavy pattern of brown spots and clouds; Sc_2 opposite two-thirds Rs; male hypopygium with a single dististyle; gonapophyses and ædeagus powerfully developed.

Male.—Length, about 3.3 millimeters; wing, 4.

Rostrum and palpi black. Antennæ with basal segments black, the flagellum brownish black, with slender segments and conspicuous verticils. Head brownish yellow.

Pronotum and mesonotum light brownish yellow, the mediotergite blackened; a narrow lateral dark line on præscutum, extending from behind the pseudosutural foveæ to beyond the wing root. Pleura more or less distinctly striped longitudinally with dark brown and obscure brownish yellow, the latter color including the dorsopleural region and a more ventral stripe ending at the halteres. Halteres pale, the knobs weakly darkened. Legs with the coxæ dark; trochanters brown, their apices paler; remainder of legs pale yellow, the femora with vague indications of a narrow, scarcely darker, subterminal ring (only the forelegs remain). Wings (Plate 1, fig. 19) yellowish cream color, handsomely variegated by dark brown spots and clouds, including areas at h, origin of Rs, Sc_2, tip of Sc_1, cord, stigmal region, a nearly continuous band along vein R_5; a cloud at fork of M_{3+4}; marginal clouds at ends of all longitudinal veins excepting R_5; conspicuous paler brown clouds in bases of cells M to 2d A, in the latter cells including all but the outer ends and a narrow white seam the entire length of vein 1st A; veins yellow, darker in the clouded areas. Venation: Sc_2 ending opposite two-thirds the length of Rs; vein 2d A rather strongly sinuous.

Abdomen brownish black, the hypopygium more yellowish. Male hypopygium (Plate 3, fig. 39) with the tergite, *9t*, at apex produced into two lateral fleshy lobes provided with long coarse setæ. Basistyle, *b*, with a single developed dististyle, this appearing as a strongly curved horn-colored hook, narrowed to the slightly dusky tip that terminates in a small seta. Phallosome, *p*, conspicuous, the apparent gonapophyses appearing as long flattened blades that are longer than the dististyle; the ædeagus is a compressed blade, on margin with a long slender extension whose limits cannot be accurately determined in the unique type.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, on mossy cliffs in river gorge, altitude 3,600 feet, July 27, 1932 (*G. M. Franck*).

The most similar described species is *Erioptera* (*Teleneura*) *nigribasis* Edwards (Malayan Subregion), which is readily distinguished by the coloration of the legs, especially the blackened femoral bases; the wing pattern, with the details quite different from the present fly, although the general plan is the same; and especially the structure of the male hypopygium, which in *nigribasis* has two dististyles and the phallosome of entirely different construction. A careful examination of the unique type of the present species has failed to reveal any trace of the outer dististyle, or of its former position if lost by breakage.

ERIOPTERA (ERIOPTERA) FUSCOHALTERATA Alexander.

Erioptera fuscohalterata ALEXANDER, Proc. U. S. Nat. Mus. 68 art. 4 (1925) 11–12, fig. 3.

Described from a single broken male, Amagu Village, Ussuri, July, 1923 (*Cockerell*). An additional male in the Russian Academy of Sciences, taken at Nikolajevsk, on Amur River, Ussuri, June 23, 1914 (*Bjeloussov*).

The species is allied to the European *Erioptera* (*Erioptera*) *fuscipennis* Meigen or *E.* (*E.*) *lutea* Meigen, but is quite distinct in the structure of the male hypopygium, especially the slender, gradually narrowed, outer dististyles.

ORMOSIA RECTANGULARIS sp. nov. Plate 1, fig. 20; Plate 3, fig. 40.

General coloration light gray; antennæ short; halteres pale yellow; wings pale yellowish white, the prearcular and costal regions clear light yellow; a restricted brown pattern on wings; R_2 at fork of R_3 and R_4; m rectangular and spurred at union with outer section of M_3; anal veins divergent; male hypopygium without a spinous apical spur on basistyle; gonapophyses appearing as long yellow rods, their bases dilated.

Male.—Length, about 4.5 millimeters; wing, 5.

Female.—Length, about 5.5 millimeters; wing, 6.

Rostrum and palpi dark brown. Antennæ short; basal segments pale brown, the flagellum darker brown; flagellar segments oval, decreasing in size outwardly. Head gray.

Mesonotum light gray, the præscutum without clearly indicated stripes; pseudosutural foveæ and tuberculate pits black. Pleura clear gray throughout. Halteres pale yellow. Legs with the coxæ pale, sparsely pruinose, especially the fore coxæ; trochanters yellow; femora obscure yellow, the tips conspicuously brownish black; tibiæ light brown, the tips darker; tarsi brownish black. Wings (Plate 1, fig. 20) pale yellowish white, the prearcular and costal regions clearer yellow; a restricted brown pattern, including the stigma, seams along cord, m, and vein Cu; poorly indicated markings at ends of outer radial veins and in axillary region; veins brown, darker in the clouded areas, pale yellow in the luteous regions. Venation: R_2 at fork of R_{3+4}; veins R_3 and R_4 deflected cephalad at margin, the former more strongly so; cell 1st M_2 open, m rectangular and spurred at union with outer section of M_3; anal veins diverging.

Abdomen, including hypopygium, dark brown. Male hypopygium (Plate 3, fig. 40) with the basistyle, *b*, not produced at apex. Dististyles small, the inner, *id*, broad, narrowed into an apical point. Gonapophyses, *g*, appearing as long straight yellow rods, their bases dilated.

Habitat.—Japan (Honshiu).

Holotype, male, Yumoto, Shimotsuke, altitude 4,850 feet, June 20, 1932 (*S. Issiki*). Allotopotype, a broken female.

In the venation of the outer radial and medial fields of the wing, the present fly agrees with a group of Japanese and Formosan species, such as *Ormosia aculeata* Alexander, *O. anthracopoda* Alexander, *O. horiana* Alexander, and *O. laevistyla* Alexander, all of which differ in the apically convergent anal veins and in the terminal spine of the basistyle of the male hypopygium.

MOLOPHILUS TRIACANTHUS sp. nov. Plate 1, fig. 21; Plate 3, fig. 41.

Belongs to the *gracilis* group and subgroup; general coloration brownish gray, the humeral region of præscutum obscure yellow; halteres yellow; wings broad; male hypopygium without spinous lobes on basistyle; both dististyles simple, the outer one on distal half with a fringe of conspicuous black setæ; phallosome with three slender black spines.

Male.—Length, about 4 to 4.2 millimeters; wing, 5.3 to 5.5.

Rostrum and palpi brown. Antennæ relatively short, dark brown throughout. Head gray.

Anterior lateral pretergites pale yellow. Mesonotal præscutum and scutum dark grayish brown, the humeral region obscure yellow; pseudosutural foveæ elongate, conspicuous; posterior border of scutellum obscure yellow; mediotergite dark gray. Pleura brownish gray. Halteres pale. Legs with coxæ and trochanters yellow; femora brownish black, the bases pale, more extensively so on posterior legs; tibiæ pale brown, the tips narrowly darker; tarsi brownish black. Wings (Plate 1, fig. 21) broad, faintly tinged with brown, the basal portions more yellowish; veins very pale brown, the prearcular and subcostal veins more yellow; macrotrichia brown, the costal fringe long and dense. Venation: Vein 2d A ending about opposite one-third the length of the petiole of cell M_3.

Abdomen brownish gray, the hypopygium somewhat more brightened. Male hypopygium (Plate 3, fig. 41) with the apical lobes of the basistyle all short and blunt, the mesal lobe small and darkened. Outer dististyle, *od*, a simple arcuated rod, the inner margin on distal half densely fringed with long black setæ. Inner dististyle, *id*, subequal in length to outer, the basal two-thirds flattened, the outer third narrowed and curved into an acute point, the surface with microscopic setulæ. Phallosome, *p*, with three slender, acute spines, one apical, the others lateral.

Habitat.—Japan (Honshiu).

Holotype, male, Yumoto, Shimotsuke, altitude 4,850 feet, June 20, 1932 (*S. Issiki*). Paratopotype, male.

Molophilus triacanthus is readily told from the other Japanese species by the large size, broad wings, and, especially, the structure of the male hypopygium. The trispinous phallosome is different from that of any other described species in eastern Asia.

MOLOPHILUS CRASSULUS sp. nov. Plate 1, fig. 22; Plate 3, fig. 42.

Belongs to the *gracilis* group and subgroup; general coloration brown; antennæ short; halteres darkened; wings with Sc_1 ending just beyond R_2; 2d A relatively short, ending opposite the caudal end of m-cu; male hypopygium with lobes of basistyle poorly developed; inner dististyle slender, at apex a little expanded into a slightly swollen bispinous head.

Male.—Length, about 3 millimeters; wing, 3.5.

Rostrum pale; palpi dark brown. Antennæ short; basal segments obscure yellow; flagellar segments dark brown. Head brownish testaceous.

Mesonotum medium brown, without clearly defined markings, the humeral region of præscutum obscure yellow. Pleura chiefly darkened, the ventral portions paler. Halteres darkened. Legs with the coxæ and trochanters yellow; remainder of legs brown, the outer tarsal segments darker. Wings (Plate 1, fig. 22) grayish yellow, the costal and prearcular regions clearer yellow; veins pale brown, the macrotrichia dark brown; costal fringe unusually long and dense. Venation: Sc_1 ending just beyond R_2, the latter about in alignment with r-m; vein 2d A relatively short, ending opposite the caudal end of m-cu.

Abdomen dark brown, the hypopygium brighter. Male hypopygium (Plate 3, fig. 42) with the dorsal and mesal lobes of basistyle scarcely developed; ventral lobe, *vb*, produced as a broadly flattened extension that is divided into two parts by a linear slit. Outer dististyle, *od*, a flattened pale blade, the distal third narrowed into an acute black spine. Inner dististyle, *id*, nearly as long but slenderer and nearly straight, the head dilated and darkened, terminating in an apical point and with a small black marginal spur at the base of the head.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, altitude 4,800 feet, July 4, 1932 (*Franck*). Paratopotype, a broken male. Allotype, female, altitude 4,200 feet, June 29, 1932. Paratypes, 6 of both sexes, altitude 4,200 feet, June 29 to July 2, 1932; 4,800 feet, July 4, 1932.

There is no very near ally of the present fly among the described regional species. The structure of the male hypopygium is distinctive.

MOLOPHILUS BARDUS sp. nov. Plate 1, fig. 23; Plate 3, fig. 43.

Belongs to the *gracilis* group and subgroup; closely allied to *costalis;* male hypopygium with the dorsal lobe of basistyle pale, not tipped with a blackened spine; both dististyles long and slender, blackened to their bases.

Male.—Length, about 3 millimeters; wing, 3.5.

Rostrum and palpi black. Antennæ with the basal segments pale, the outer segments darker. Head brownish yellow.

Mesonotum and pleura almost uniformly pale brown. Halteres pale. Legs with coxæ and trochanters pale; remainder of legs broken. Wings (Plate 1, fig. 23) with a grayish yellow tinge, the costal border clear light yellow; cells near wing base more darkened; veins pale, darker in the basal areas. Venation: R_2 and r-m about in transverse alignment.

Abdomen brown, the hypopygium brighter. Male hypopygium (Plate 3, fig. 43) much as in *costalis*, differing in the pale-tipped, more obtuse, dorsal lobe, *db*, of the basistyle and the slightly longer and slenderer, entirely blackened dististyles.

Outer dististyle, *od*, very long and slender, gradually narrowed into a long slender spine. Inner dististyle, *id*, a trifle shorter, broader on basal half, the outer half slenderer and sinuous, the outer margin with a few appressed teeth.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, on mossy cliffs in river gorge, altitude 3,600 feet, July 27, 1932 (*Franck*).

Although closely allied to *Molophilus costalis* Edwards (Formosa), the present species is readily distinguishable by the details of the male hypopygium.

Genus TOXORHINA Loew

Toxorhina Loew, Linnæa Entomol. 5 (1851) 400.

Subgenus EUTOXORHINA novum

Characters as in the typical subgenus, differing in the complete loss of vein and cell M_3, there being only two radial and two medial veins reaching the wing margin.

Type of subgenus.—*Toxorhina* (*Eutoxorhina*) *simplex* sp. nov. (Australasian Region: Fiji).

The present group shows the greatest reduction in longitudinal veins of wing of any known crane fly, there being but eight reaching the margin (Sc_1, R_{1+2}, R_5, M_{1+2}, M_4, Cu_1, 1st A, and 2d A). Other groups of Tipulidæ that show a notable reduction in number of veins (as *Limonia: Alexandria* Garrett, *Orimarga: Diotrepha* Osten Sacken, and *Hexatoma: Cladolipes* Loew) have an additional branch of R preserved and so have nine longitudinal veins attaining the margin.

The three known subgenera of *Toxorhina* may be separated as follows:

1. Wings with two branches of Rs (R_3 and R_5) reaching the margin (tropicopolitan) .... *Ceratocheilus* Wesché.
   Wings with a single branch of Rs (R_5) reaching the margin........ 2.
2. Three medial veins (M_{1+2}, M_3, M_4) reaching the margin (almost cosmopolitan) .... *Toxorhina* Loew.
   Two medial veins (M_{1+2}, M_4) reaching the margin (Australasian). *Eutoxorhina* subgen. nov.

TOXORHINA (EUTOXORHINA) SIMPLEX sp. nov. Plate 1, fig. 24.

The unique type has lost the head and most of the abdomen.

Mesonotum chiefly reddish brown, the pleura blackened. Halteres pale yellow, the knobs weakly infuscated. Femora black, with a darker brown, nearly terminal ring, the extreme tips pale; remainder of legs brown. Wings (Plate 1, fig. 24) with a strong brownish tinge, cells Cu, 1st A, and 2d A somewhat paler; a delicate pale streak in cell M, crossing m-cu into extreme base of cell M_4; a darker brown cloud on r-m and basal section of M_{1+2} veins dark brown, more yellowish in the costal region. Basal abdominal tergites brown, the corresponding sternites blackened; abdomen broken beyond the second segment.

Habitat.—Fiji.

Holotype, sex?, Coli-i-Siva, June 20, 1924 (*E. H. Bryan, Jr.*). Type in Bishop Museum, Honolulu.

ILLUSTRATIONS

[Legend: *a*, Ædeagus; *b*, basistyle; *d*, dististyle; *db*, dorsal lobe of basistyle; *g*, gonapophysis; *i*, interbase; *id*, inner dististyle; *mb*, mesal lobe of basistyle; *md*, intermediate dististyle; *od*, outer dististyle; *p*, phallosome; *t*, tergite; *vb*, ventral lobe of basistyle; *vd*, ventral dististyle.]

PLATE 1

FIG. 1. *Limonia* (*Geranomyia*) *unifilosa* sp. nov.; venation.
2. *Limonia* (*Geranomyia*) *baliana* sp. nov.; venation.
3. *Limonia* (*Geranomyia*) *vanikorensis* sp. nov.; venation.
4. *Limonia* (*Pseudoglochina*) *bryophila* sp. nov.; venation.
5. *Orimarga* (*Orimarga*) *nudivena* sp. nov.; venation.
6. *Orimarga* (*Orimarga*) *æquivena* sp. nov.; venation.
7. *Pedicia* (*Nasiternella*) *hokkaidensis* sp. nov.; venation.
8. *Dicranota* (*Rhaphidolabis*) *platymera* sp. nov.; venation.
9. *Pseudolimnophila mobilis* sp. nov.; venation.
10. *Pseudolimnophila yumotana* sp. nov.; venation.
11. *Pseudolimnophila erecta* sp. nov.; venation.
12. *Limnophila* (*Prionolabis*) *sôunkyana* sp. nov.; venation.
13. *Limnophila* (*Prionolabis*) *luteibasalis* sp. nov.; venation.
14. *Limnophila* (*Prionolabis*) *inermis* sp. nov.; venation.
15. *Limnophila* (*Tricholimnophila*) *prionolaboides* sp. nov.; venation.
16. *Elephantomyia* (*Elephantomyodes*) *mackerrasi* sp. nov.; venation.
17. *Gonomyia* (*Gonomyia*) *obscuriclava* sp. nov.; venation.
18. *Gonomyia* (*Lipophleps*) *jacobsoniana* sp. nov.; venation.
19. *Erioptera* (*Teleneura*) *perornata* sp. nov.; venation.
20. *Ormosia rectangularis* sp. nov.; venation.
21. *Molophilus triacanthus* sp. nov.; venation.
22. *Molophilus crassulus* sp. nov.; venation.
23. *Molophilus bardus* sp. nov.; venation.
24. *Toxorhina* (*Eutoxorhina*) *simplex* sp. nov.; venation.

PLATE 2

FIG. 25. *Limonia* (*Geranomyia*) *unifilosa* sp. nov.; male hypopygium.
26. *Limonia* (*Geranomyia*) *baliana* sp. nov.; male hypopygium.
27. *Limonia* (*Pseudoglochina*) *bryophila* sp. nov.; male hypopygium.
28. *Orimarga* (*Orimarga*) *nudivena* sp. nov.; male hypopygium.
29. *Pedicia* (*Nasiternella*) *hokkaidensis* sp. nov.; male hypopygium.
30. *Dicranota* (*Rhaphidolabis*) *platymera* sp. nov.; male hypopygium.
31. *Pseudolimnophila mobilis* sp. nov.; male hypopygium.
32. *Pseudolimnophila yumotana* sp. nov.; male hypopygium.
33. *Limnophila* (*Prionolabis*) *sôunkyana* sp. nov.; male hypopygium.

PLATE 3

FIG. 34. *Limnophila (Prionolabis) luteibasalis* sp. nov.; male hypopygium.
35. *Limnophila (Prionolabis) inermis* sp. nov.; male hypopygium.
36. *Limnophila (Tricholimnophila) prionolaboides* sp. nov.; male hypopygium.
37. *Gonomyia (Lipophleps) jacobsoniana* sp. nov.; male hypopygium.
38. *Gonomyia (Lipophleps) acuspinosa* sp. nov.; male hypopygium.
39. *Erioptera (Teleneura) perornata* sp. nov.; male hypopygium.
40. *Ormosia rectangularis* sp. nov.; male hypopygium.
41. *Molophilus triacanthus* sp. nov.; male hypopygium.
42. *Molophilus crassulus* sp. nov.; male hypopygium.
43. *Molophilus bardus* sp. nov.; male hypopygium.

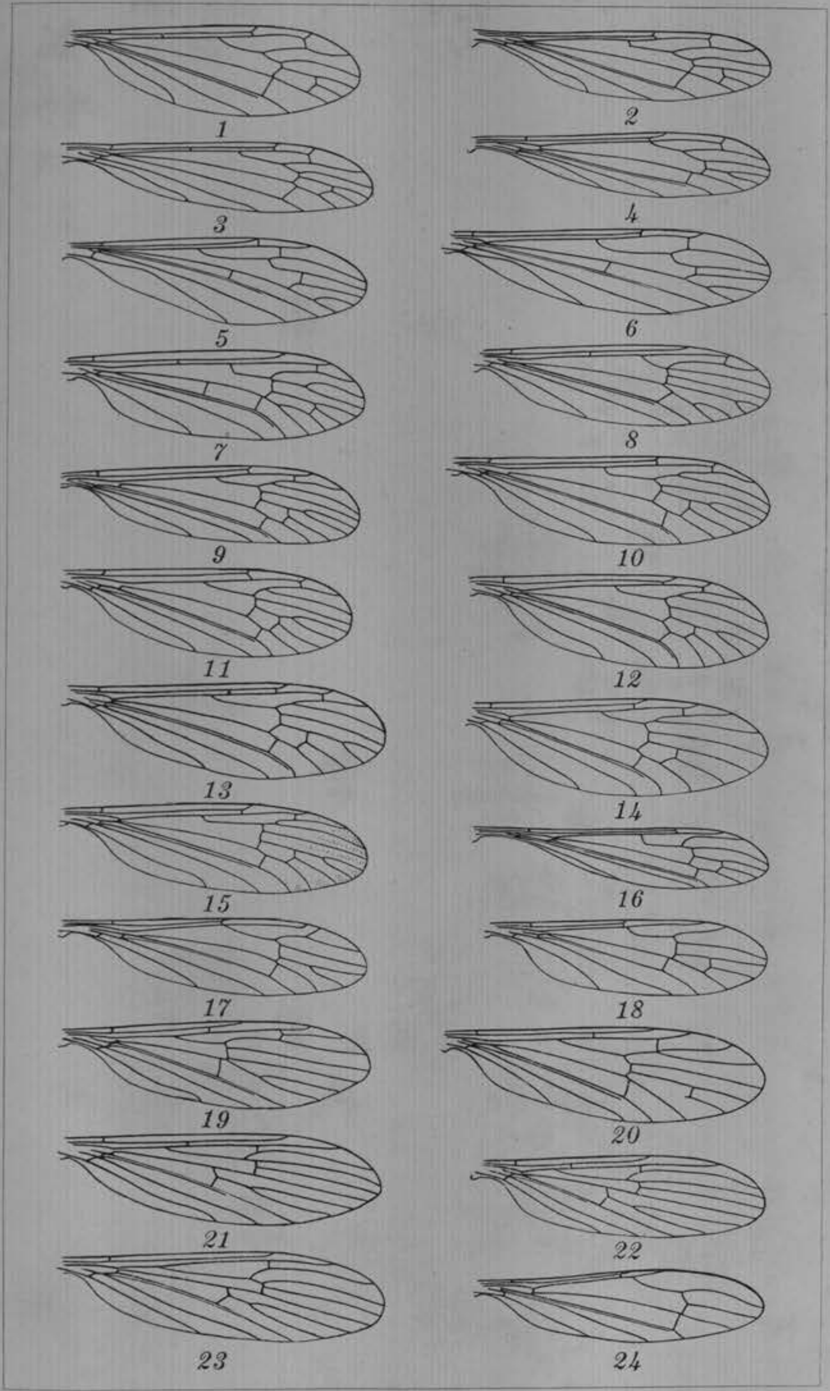


PLATE 1.

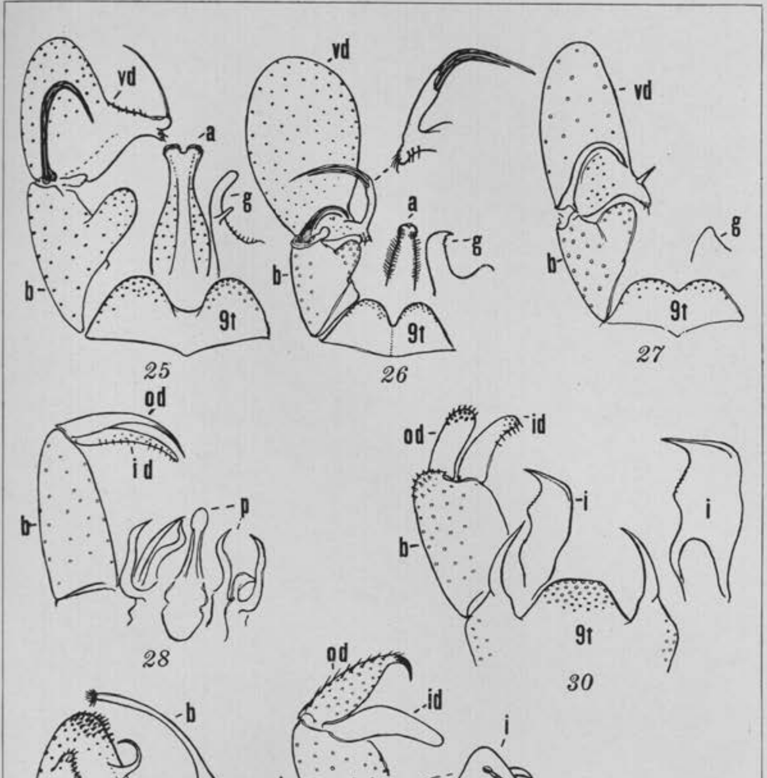

vd
a
g
b
9t
25
vd
a
g
b
9t
26
vd
g
b
9t
27
od
id
p
b
28
od
id
i
i
b
9t
30
b
b
i
29
od
id
i
b
9t
31
od
id
i
b
b
9t
32
od
id
a
g
b
9t
33

PLATE 2.

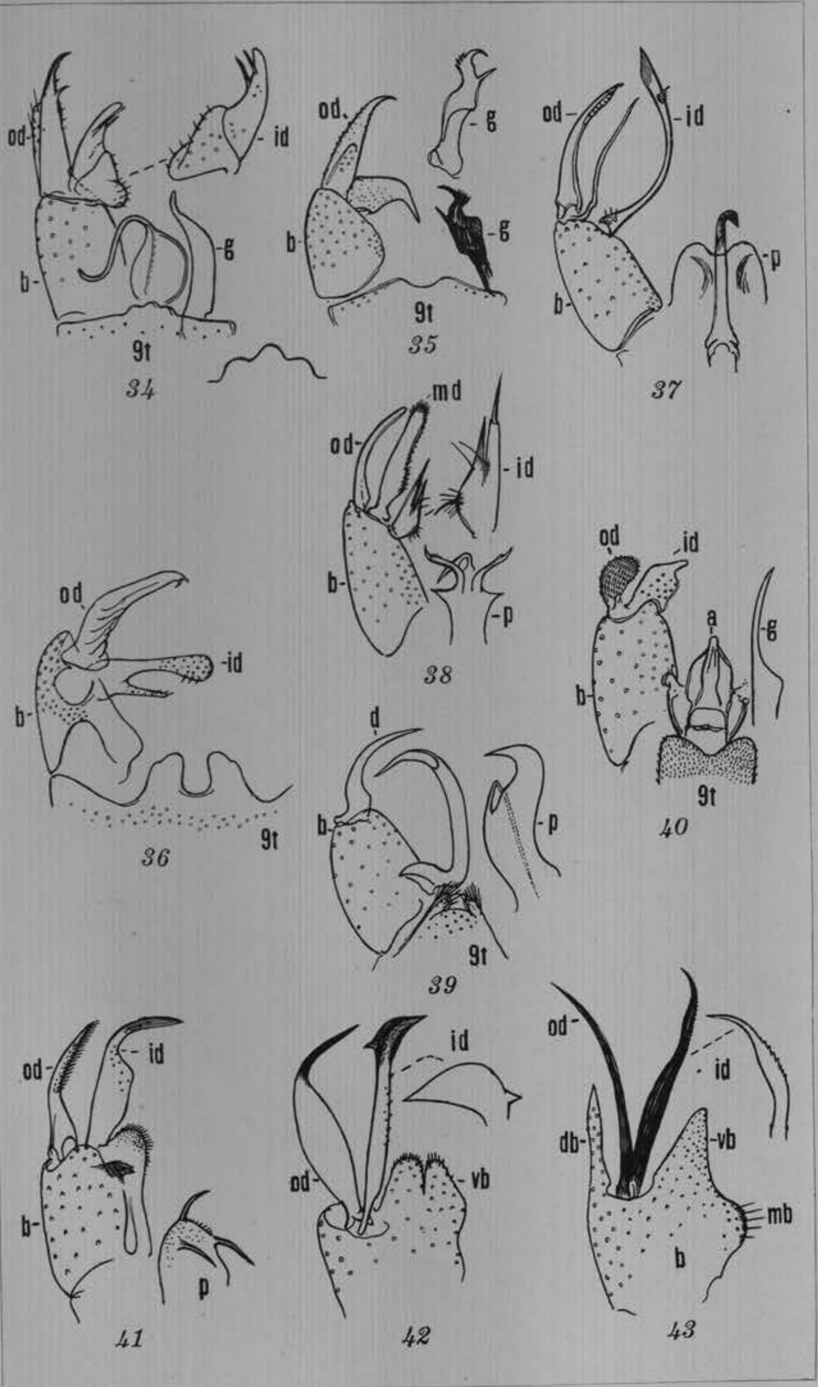

od
id
b
g
9t
34
od
g
b
g
9t
35
od
id
b
p
37
md
od
id
b
p
38
od
id
b
9t
36
od
id
a
g
b
9t
40
d
b
p
9t
39
od
id
b
p
41
id
od
vb
42
od
id
db
vb
mb
b
43

PLATE 3.

THE GENUS PEDICIA WITH SPECIAL REFERENCE TO THE JAPANESE SPECIES OF THE GENUS (DIPTERA: TIPULIDÆ)

By SHOJIRO KARIYA

Of the Nawa Entomological Laboratory, Gifu

ONE PLATE

Since the genus *Pedicia* based on the European *Tipula rivosa* Linnæus was established by Latreille in 1809, ten species of the genus have been described from various parts of the world.

In the Japanese Empire, the genus *Pedicia* is represented by three known species; namely, *P. daimio* Matsumura, *P. brachycera* Alexander, and *P. subtransversa* Alexander. *Pedicia daimio* Matsumura was described from Hokkaido, as the type of the new genus *Daimiotipula,* the identity of which with *Pedicia* was later pointed out by C. P. Alexander. *Pedicia brachycera* Alexander and *P. subtransversa* Alexander were described from the materials taken in the "Japanese Alps," Honshu, by J. Machida.

In the course of my study of the Tipulidæ preserved in the Nawa Entomological Laboratory, Gifu, I found two male specimens belonging to this genus, which are evidently specifically distinct from each other and are apparently new to science. Fortunately, several specimens of one of these species have been collected on Mount Kinkwa, Gifu, by Mr. H. Ise and myself since that time. One male specimen from the Prefecture Iwate presented to me by Mr. T. Kato is also referable to this species. Another male specimen, taken at Hakone by Mr. H. Sawada, is slightly different from the specimens collected at Gifu, and may be treated as representing a subspecies. I have also examined material from Saghalien, through the courtesy of Dr. T. Uchida and Mr. I. Okada, and the species represented in this material seems to be identical with *P. cockerelli* Alexander from Siberia.

In the present paper two new species, one new subspecies, and one new to the fauna of the empire are described, and it may be safe to say that six species and one subspecies of the genus inhabit the Japanese Empire. Further, a description of the genus, a list of the species hitherto known of the world, and a key to the Japanese species are also given.

I am very much indebted to Dr. J. Shibuya for his kind help in preparing the manuscript of this paper, and especially to Prof. Dr. T. Esaki and Prof. Dr. C. P. Alexander for their valuable suggestions for the present study. Further, I wish to express my hearty thanks to Mr. K. Yasumatsu for the trouble he took in preparing copies of some needed literature and drawings of certain species of *Pedicia;* and also to Dr. T. Uchida, Messrs. U. Nawa, M. Ishida, I. Okada, H. Sawada, N. Mori, T. Kato, and H. Ise for their kind coöperation in various ways.

LIMONIINÆ

PEDICIINI

Genus PEDICIA Latreille

Pedicia LATREILLE, Gen. Crust. Ins. 4 (1809) 255.
Daimiotipula MATSUMURA, Thousand Ins. Japan, add. 2 (1916) 463.

Very near to *Tricyphona* Zetterstedt, but may be distinguished by much larger size and by the possession of the characteristic wing pattern of this genus.

Genotype.—*Tipula rivosa* (Linnæus).

Head small, somewhat roundish; vertex with a distinct tubercle; occiput extended caudad. Rostrum very short; palpi with the terminal segment usually greatly elongated. Antennæ rather short, 15- or 16-segmented; scape long and stout, cylindrical, bearing many bristles, chiefly on its dorsal part; pedicel long, cup-shaped, with many bristles; flagellar segments short and crowded, but several terminal segments usually somewhat elongated; first to eighth segments of the flagellum each bearing only a few long bristles, remaining terminal segments provided with the verticillate hairs which are elongated and conspicuous.

Wings with brown bands on the anterior margin, cord, and on vein Cu; these bands are connected with each other and make up the pattern characteristic of the genus. Wing venation closely allied to that of some species of *Tricyphona:* Sc_2 before or slightly beyond the origin of Rs; Rs usually ending in cell R_{2+3}, sometimes in alignment with petiole of cell R_4; cell R_4 shortly petiolate, rarely sessile; cord usually oblique; cell M_1 petiolate; cell 1st M_2 usually short and pentagonal. Basal part of Rs and two anal veins bearing no setæ, rarely very sparsely bristled.

Legs rather stout and hairy; tibial spurs conspicuous; claws simple.

Male hypopygium stout and hairy, upturned; basistyle with many strong bristles on its dorsoapical angle, the ventroapical angle produced into a shiny, acutely pointed horn, otherwise dististyle extremely terminal in position. Ovipositor with the apical third slightly curved upwards, the apex rather obtuse.

The species belonging to this genus are among the largest of the subfamily Limoniinæ and spread the wings even in repose. As far as I am concerned thirteen species and one subspecies are at present known to occur in the world, and all of them are restricted to the Holarctic Region.

List of the species of the genus Pedicia.

1. **PEDICIA RIVOSA Linnæus. Europe.**

Tipula rivosa LINNÆUS, Syst. Nat., ed. 10 (1758) 586.
Limonia rivosa MEIGEN, Klassif., Beschr. europ. zweifl. Ins. 1 (1804) 62, pl. 3, fig. 14.
Pedicia rivosa LATREILLE, Gen. Crust. Ins. 4 (1809) 255.
Limnobia rivosa MEIGEN, Syst. Beschr. europ. zweifl. Ins. 1 (1818) 118, 119, pl. 4, fig. 14.
Pedicia rivosa V. D. WULP, Diptera Neerland. 1 (1877) 487, 488, pl. 11, fig. 11.

2. **PEDICIA ALBIVITTA Walker. North America (Canada).**

WALKER, List Dipt. Brit. Mus. 1 (1848) 37.
ALDRICH, Psyche 7 No. 226 (1895) 201, 1 fig.
ALEXANDER, Cornell Univ. Agr. Exp. Sta., Memoir 25 (1919) 923, fig. 175.

3. **PEDICIA CONTERMINA Walker. North America (Canada).**

WALKER, List Dipt. Brit. Mus. 1 (1848) 38.
ALEXANDER, Cornell Univ. Agr. Exp. Sta., Memoir 25 (1919) 923, fig. 176.

4. **PEDICIA OBTUSA Osten Sacken. North America (California).**

OSTEN SACKEN, U. S. Geol. Geogr. Surv. 3 No. 2 (1877) 205, 206.
ALDRICH, Psyche 7 No. 226 (1895) 202.
OSTEN SACKEN, Psyche 7 No. 228 (1895) 229, 230.

5. **PEDICIA MAGNIFICA Hine. North America.**

HINE, Ohio Naturalist 3 (1903) 416, 417.

6. **PEDICIA DAIMIO Matsumura. Japan (Hokkaido).**

Daimiotipula daimio MATSUMURA, Thous. Ins. Japan, add. 2 (1916) 462, 463, pl. 25, fig. 5, female.
Pedicia daimio ALEXANDER, Philip. Journ. Sci. 24 (1924) 568, 569, male.
Daimiotipula daimio MATSUMURA, 6000 Illust. Ins. Japan-Empire (1931) 393, fig. 248.
Pedicia daimio ESAKI, Iconogr. Ins. Jap. (1932) 197, fig. 383.

7. **PEDICIA ARCTICA** Frey. Lapland (Ponoi).
FREY, Notulae Entomol. 1 No. 4 (1921) 110, 111, 4 figs.

8. **PEDICIA COCKERELLI** Alexander. Siberia (Olga), Japan (Saghalien).
ALEXANDER, Proc. U. S. Nat. Mus. 68 Art. 4 (1925) 9, 10, pl. 1, fig. 2.

9. **PEDICIA MARGARITA** Alexander. North America (Massachusetts).
ALEXANDER, Bull. Brooklyn Ent. Soc. 24 No. 5 (1929) 300–302, with a key for three species inhabiting northeastern North America.

10. **PEDICIA BRACHYCERA** Alexander. Japan (Honshu).
ALEXANDER, Philip. Journ. Sci. 50 (1933) 145, 146, pl. 1, fig. 12; pl. 3, fig. 40.

11. **PEDICIA SUBTRANSVERSA** Alexander. Japan (Honshu).
ALEXANDER, Philip. Journ. Sci. 50 (1933) 146, 147, pl. 1, fig. 13; pl. 3, fig. 41.

12. **PEDICIA NAWAI** Kariya, sp. nov. Japan (Honshu).

13. **PEDICIA GIFUENSIS** Kariya, sp. nov. Japan (Honshu).

13a. **PEDICIA GIFUENSIS SAWADAI** Kariya, subsp. nov. Japan (Honshu).

The Japanese species of *Pedicia* may be separated by the following key, chiefly based on the wing characters.

Key to the Japanese species of the genus Pedicia.

1. Brown seam along vein Cu prolonged to the wing margin .... 2.
Brown seam along vein Cu becoming obsolete before midlength of the vein and not reaching the margin .... *brachycera* Alexander.
2. Cord oblique, cell 1st M_2 very short, pentagonal .... 3.
Cord subtransverse, cell 1st M_2 elongate, hexagonal .... 4.
3. Brown spot at the origin of Rs not attaining to vein M .... 5.
Brown spot at the origin of Rs attaining or scarcely attaining to vein M .... 6.
4. Antennæ uniformly yellowish brown .... *cockerelli* Alexander.
Antennæ with the scape and pedicel black .... *subtransversa* Alexander.
5. Spot described above small and roundish; brown seam along vein Cu slightly dilated at wing margin; size small .... *nawai* sp. nov.
The spot not roundish; brown seam along vein Cu not dilated at wing margin; size large .... *daimio* Matsumura.
6. Brown spot attaining to M; brown seam along vein Cu attached to vein 1st A at wing margin .... *gifuensis* sp. nov.
Brown spot scarcely attaining to M; brown seam along vein Cu not widened at wing margin .... *gifuensis sawadai* subsp. nov.

PEDICIA NAWAI sp. nov. Plate 1, figs. 1 and 5.

Related to *daimio* Matsumura; size smaller; general coloration grayish yellow; dark markings on the wing narrow and pale, isolating a pale spot in cell R_1 as in *daimio*.

Male.—Length, about 17 mm; wing, 17.

Head, rostrum, and palpi blackish brown. Antennæ yellowish brown, basal two segments obscurely yellow; flagellar segments tapering distad; several terminal segments with conspicuous verticils. Vertical tubercle distinct.

Thorax pinkish testaceous, gray pruinose. Præscutum with three dark brown stripes, the intermediate stripe feebly separated by a capillary pale line; lateral stripes extending as far as the scutal lobes across the suture; scutellum yellow; postnotum testaceous. Pleura testaceous, gray pruinose. Halteres pale yellow. Legs with the coxæ and trochanters yellowish brown; femora yellow, tips darkened; tibiæ and tarsi dark brown. Wings (fig. 1) of the usual *Pedicia*-pattern; the costal margin much paler than the remaining dark markings, the humeral region pale yellow; brown seam along vein Cu somewhat widened at the wing margin; a projecting spot at the origin of Rs roundish; cell R_1 with a pale spot at the root of the seam along the cord, as in *daimio*. Venation: Rs angulated and short-spurred at origin; petiole of cell M_1 nearly equal to m.

Abdomen yellowish brown, the caudal half fuscous; basal tergites with a median dark stripe. Male hypopygium (fig. 5) dark brown, dorsoapical angle of basistyle with a small group of yellow setæ. Dististyle (fig. 5, *d*) rather large and rectangular, with a small bladelike protuberance on ventral mesal face.

Habitat.—Japan (Honshu).

Holotype, male, Mount Ontake, Province Hida, April 16, 1897 (*Y. Nawa*), in the Nawa Entomological Laboratory, Gifu.

The present species is named in honor of the former director of the laboratory, the late Y. Nawa.

PEDICIA GIFUENSIS sp. nov. Plate 1, figs. 2, 6, 7, and 8.

Allied to *daimio* Matsumura; general coloration grayish ocherous; wings with the pattern broad and dark brown, with a pale spot in cell R_1.

Male.—Length, about 26 mm; wing, 24.

Female.—Length, 28 mm; wing, 23.

Rostrum, palpi, and head blackish brown. Antennæ dark yellowish brown, basal two segments fuscous. Female antennæ (fig. 7) similar to those of the male, apparently 15-segmented. The vertical tubercle with a circular depression.

Pronotum testaceous, dark brown medially; præscutum ocherous yellow, with three brown stripes, the intermediate one distinctly dark gray; lateral stripes crossing the suture onto scutum; scutellum yellow; postnotum rusty yellow, median spot tinged with gray. Pleura yellowish ocherous, white pruinose.

Halteres pale yellow. Legs with coxæ and trochanters testaceous; femora yellow, tips distinctly blackened, more broadly and conspicuously on the fore femora, more narrowly and abruptly on the hind femora; tibiæ and tarsi blackish brown. Wings (fig. 2) with the usual pattern of the genus; the pattern broader than in *daimio*, with a minute pale spot in cell R_1; humeral region pale yellow; the spot at origin of Rs attains to M; band along vein Cu touching vein 1st A at wing margin. Venation: Petiole of cell M_1 subequal to m.

Abdomen testaceous; tergites with a nearly continuous median brown stripe, sternites similar; terminal segments passing into dark brown. Male hypopygium (fig. 6) with basistyle stout; dorsoapical angle of basistyle produced into an obtuse jut that is less densely provided with yellow setæ. Dististyle (fig. 6, *d*) dark brown, heavily sclerotized, with a small projection on ventral mesal face, the ventral face sole-shaped, the apex shiny, provided with three or four minute spines. Ovipositor (fig. 8) with the tergal valves slightly upturned at the tip.

Habitat.—Japan (Honshu).

Holotype, male, Mount Kinkwa, Gifu, September 30, 1901 (*U. Nawa*).

Allotopotype, female, May 27, 1932 (*S. Kariya*).

Paratopotypes: 1 male, April 13, 1932 (*S. Kariya*); 2 males, April 29, 1932 (*S. Kariya*); 1 female, May 12, 1933 (*H. Ise*). Paratype, 1 male, Pref. Iwate, August 25, 1933 (*T. Kato*).

Two male paratopotypes from Mount Kinkwa are apparently devoid of the pale spot in cell R_1, but no other difference even of subspecific significance between these specimens and the holotype can be detected. Holotype in the Nawa Entomological Laboratory, Gifu; other specimens in my collection.

PEDICIA GIFUENSIS SAWADAI subsp. nov. Plate 1, fig. 3.

Male.—Length, 24 mm; wing, 21.

Similar to *P. gifuensis* in general, but differs from the latter as follows:

Size slightly smaller; wings (fig. 3) with the seams along vein Cu and the cord narrower, the former not widened at the wing margin; pale spot in cell R_1 larger; the spot at origin of Rs scarcely extending to M. Venation: Petiole of cell M_1 a little longer than m; cross vein m-cu just before the fork of M.

Habitat.—Japan (Honshu).

Holotype, male, Gora, Hakone, May 17, 1932 (*H. Sawada*), in my collection.

This subspecies is named in honor of Mr. H. Sawada, who has presented to me many interesting crane flies from Hakone.

PEDICIA COCKERELLI Alexander. Plate 1, figs. 4 and 9.

Pedicia cockerelli ALEXANDER, Proc. U. S. Nat. Mus. 68 Art. 4 (1925) 9, 10, pl. 1, fig. 2.

Holotype, a male, taken from Olga, Siberia.

Four males, Kashiho, Saghalien, July 10–11, 1933 (*T. Uchida* and *I. Okada*). These specimens agree well with Alexander's description except in the wing venation (fig. 4), which may apparently be very variable in this species. The species is distinct from the other Japanese species of *Pedicia* in the coloration of the body, unicolored antennæ, somewhat vague markings of the wings, and the structure of the male hypopygium (fig. 9). Although the species is closely allied to *P. rivosa* Linnæus (Europe), it differs from the latter in the coloration of the body, antennæ, and legs, as well as in the structure of the male hypopygium, especially in the details of the ventroapical horn of the basistyle (fig. 9, *h*) and the extended dististyle (fig. 9, *d*).

Three of the four specimens from Saghalien mentioned above are preserved in the Entomological Institute of the Hokkaido Imperial University, Sapporo, and one is in my collection.

ILLUSTRATION

PLATE 1

FIG. 1. *Pedicia nawai* sp. nov., wing.
2. *Pedicia gifuensis* sp. nov., wing.
3. *Pedicia gifuensis sawadai* subsp. nov., wing.
4. *Pedicia cockerelli* Alexander, wing.
5. *Pedicia nawai* sp. nov., male hypopygium, lateral aspect.
6. *Pedicia gifuensis* sp. nov., male hypopygium, lateral aspect.
7. *Pedicia gifuensis* sp. nov., female antenna.
8. *Pedicia gifuensis* sp. nov., ovipositor.
9. *Pedicia cockerelli* Alexander, male hypopygium, ventral aspect.

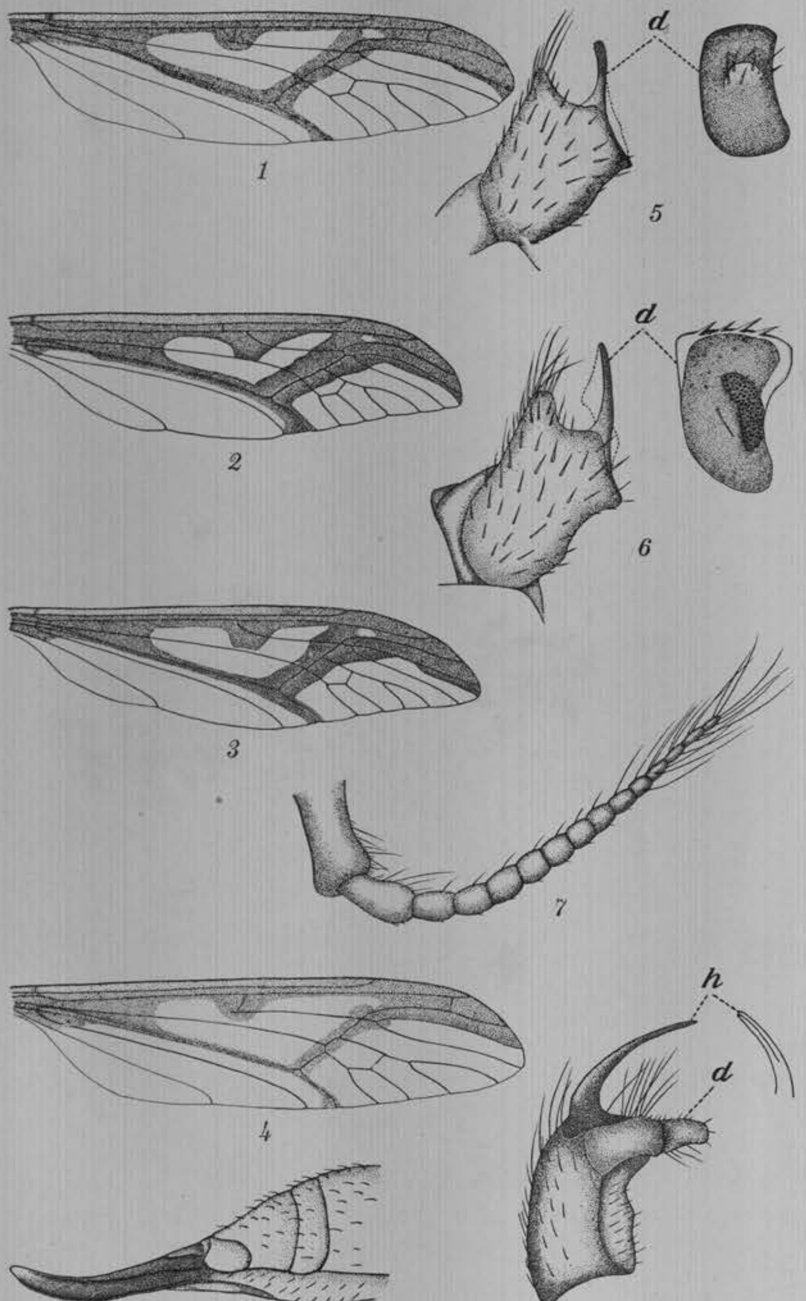


PLATE 1.

THIRTEENTH CONTRIBUTION TO THE COLEOPTERA FAUNA OF THE PHILIPPINES

By W. SCHULTZE
Of Bad Tölz, Germany

TWO PLATES

In this paper I am reporting new species of Cerambycidæ and Curculionidæ from the Philippine Islands. Unless otherwise stated, the material was collected by A. de los Reyes and A. Duyag, who have previously been collecting for me. It again includes a number of pachyrrhynchids. On Plate 2 are given side views of the new species in schematic form, in the same relative size as in my monograph on pachyrrhynchids.[1] Through the figures the identifications in this group, which contains many species, are greatly facilitated. The types of all species described herein are represented in my collection. The following new species are described in this paper:

CERAMBYCIDÆ

Pseudabryna hieroglyphica.
Cylindrepomus sexlineatus.
Niphonoclea ornata.
Proteuclea palawana.
Acronia luzonica.
Pseudodoliops schwarzeri.

CURCULIONIDÆ

Pachyrrhynchus monilifer stellulifer var. *neojugifer.*
Pachyrrhynchus rizali.
Pachyrrhynchus bucasanus ornatus.
Pachyrrhynchus galeraensis.
Pachyrrhynchus davaoensis.
Pachyrrhynchus regius var. *borongaus.*
Macrocyrtus trilineatus.
Apocyrtus chapmani.
Proapocyrtus luzonicus.
Metapocyrtus casiguranus.
Metapocyrtus herrei.
Metapocyrtus dibagonus.
Metapocyrtus prolongatus.
Metapocyrtus tumorosus.
Metapocyrtus mumunganus.
Metapocyrtus reyesi daconus.
Metapocyrtus iridanus.
Metapocyrtus subpilosus.
Metapocyrtus duyagi.
Metapocyrtus subspinipes.
Metapocyrtus multimaculatus.
Metapocyrtus tristis.
Metapocyrtus corpulentus.
Metapocyrtus perarmatus.
Metapocyrtus alabatanus.
Metapocyrtus breviarmatus.
Celebia samarana.
Coptorhynchus ornatus.
Alcides duyagi.
Alcides negrosensis.
Alcides subcuprinus.
Alcides lagunensis.

---

[1] Philip. Journ. Sci. 23 (1923) 609–673, pls. 1–6; 24 (1924) 309–366, pls. 7–9; 25 (1924) 359–390, pls. 1–2; 26 (1925) 131–309, pls. 1–12.

CERAMBYCIDÆ

PSEUDABRYNA HIEROGLYPHICA sp. nov. Plate 1, fig. 6.

Related to *P. luzonica* Schultze.[2] Glossy black with white tomentose markings. Head irregularly scattered-punctate, Front with a white longitudinal tomentose stripe extending to the vertex. The latter with a fine glistening longitudinal callosity medially. Prothorax somewhat broader than long, subcylindrical, glossy, remotely scattered-punctate. On the sides, next to the anterior margin, a narrow tomentose stripe, and over the anterior coxæ a spot. Elytra faintly glossy, in the basal third irregularly punctate, the punctation coarsest behind the humeral projections, and, gradually becoming finer, continuing on the dorsolateral slope of the elytra to the apical third. In the basal third of the elytra a crossbandlike combination of tomentose lines and stripes partly spotlike expanded. The bandlike markings united along the outer margins by a tomentose line; a tomentose stripe along the suture. Behind the middle of the elytra a further crossbandlike combination of two zigzag lines; from the middle to the apex a narrow sutural and lateral marginal stripe; and in the apical fourth of each elytron two small oblong spots. Femora with several oblong tomentose spots in the basal half. Second tarsal joints entirely and the claw joints partly white tomentose.

Length, 13.7 mm; shoulder breadth, 5.

LUZON, Nueva Vizcaya Province, Balete Pass (*W. Schultze*).

This species can readily be distinguished from *P. luzonica* Schultze by the bandlike zigzag markings.

CYLINDREPOMUS SEXLINEATUS sp. nov. Plate 1, fig. 3.

Head, antennæ, prothorax, legs, and underside light red-brown, elytra dark brown with pale yellowish tomentose stripes. Head with a fine sharp median groove extending from the anterior margin to the vertex. First antennal joint externally densely granulate. Prothorax cylindrical, longer than broad laterally, very shallow near the anterior margin, very strongly constricted near the posterior margin all around, and on either side on the constriction a round tomentose spot. Prothorax mesodorsally and on the sides minutely transversely furrowed. Scutellum semicircular, the margins slightly upturned. Elytra, with the exception of a narrow border along the suture and the apical part, densely and evenly punctate. Each elytron at the apex markedly reduced and coming to a sharp point, which diverges from the point of the other elytron. On each elytron dorsally a longitudinal tomentose stripe, which extends from the base to before the middle, then, after a short interruption, continues to near the apical part, and finally, after another interruption, ends as a small spot before the pointed apex. A further, very much shortened, longitudinal stripe lateral and parallel to the first mentioned in the apical half of the elytra.

---

[2] Philip. Journ. Sci. § D 11 (1916) 347.

Length, 13.5 mm; shoulder breadth, 3.6.

MINDANAO, Lanao Province, Mumungan (*W. Schultze*).

NIPHONOCLEA ORNATA sp. nov. Plate 1, fig. 5.

Ground color red-brown, prothorax velvety black, each elytron with two small basal black tomentose spots and a large eyespot bordered with light brownish. Head scatteredly punctate, with a narrow, shining longitudinal callosity medially, light brownish tomentose; punctation partly concealed by the toment. The black tomentation of the prothorax on the posterior margin medially interrupted by a triangular light brownish spot, and blending laterally into the red-brown ground color. Elytra pronouncedly and fairly regularly punctate. Of the two basal black tomentose spots on each elytron, the dorsal one is oblong oval and the other compactly V-shaped, lying laterally behind the humeral hump near the lateral margin. The two spots are partly bordered by a light brown toment. Behind the middle a large roundish spot also bordered anteriorly and laterally by a light brownish band; the part of the elytra lying between this spot and the apex, red-brown tomentose, also the legs.

Length, 16.7 mm; shoulder breadth, 5.6.

SAMAR, Borongan.

This species is easily distinguishable from the others of the genus by its peculiar markings.

PROTEUCLEA PALAWANA sp. nov. Plate 1, fig. 7.

Black with white tomentose markings. Head intricately scattered-punctate, front of head and vertex faintly white tomentose, lateral margins of front and sides of head more pronounced tomentose. Front medially with a fine longitudinal callosity extending to the vertex. Fourth joint of antenna for three-fourths of its length white tomentose. Prothorax one-fourth broader than long, coarsely confused punctate, with a short compact thorn on either side next to the anterior margin. Toment extremely faint, only partially dense and forming small white dots dorsally denser and appearing white laterally; a narrow white tomentose stripe along the posterior margin. Elytra pronouncedly and regularly remotely punctate, extremely faint; only the puncture margins more pronouncedly tomentose, and, irregularly scattered over the elytra, small round tomentose spots, which become more numerous in the apical part. On the lateral margin in the basal third a large oblong tomentose spot terminating in a triangular figure. Behind the middle of each elytron a transverse band spreading out in the form of a wedge to the lateral margin. Underside of pro-, meso-, and metathorax, as well as the abdominal segments lateral, white tomentose, the legs less markedly so.

Length, 13.8 mm; width, 4.6.

PALAWAN, Iwahig (*C. M. Weber*).

ACRONIA LUZONICA sp. nov. Plate 1, fig. 1.

Head, prothorax, and legs glossy black, elytra dull black with a faint and indistinct silver-gray transverse band. Front irregularly, coarsely scattered-punctate, the punctation finer and sparser toward the vertex. The latter with a faintly marked, longitudinal furrow medially. Next to the mandibular base several white toment hairs, and below the lower half of the eye an oblong white tomentose spot. A further small indistinct tomentose spot before the upper half of the eye. Antenna black, the first and third joints below and the fourth in the basal half white tomentose; third to the last joint near the apex sparsely beset with black setæ. Prothorax very glossy, lateral sparsely, scatteredly punctate, sides with a sharply marked anteromarginal groove. Laterally at the posterior margin a white tomentose stripe. Elytra irregularly scattered-punctate and very minutely black tomentose, except a poorly delimited fine light gray tomentose crossband medially. The anterior margin of the crossband is more sharply set off, the former on each elytron has a sickle-shaped white tomentose spot. On the outer margin of the elytra in the apical third a small triangular white tomentose spot. Apical margin also white tomentose. Anal segment with a mesal groove terminating in a triangular depression. The latter white tomentose, and on either side an oblong tomentose patch.

Length, 19 mm; shoulder breadth, 7.

LUZON, Cagayan Province, Peñablanca.

Genus PSEUDODOLIOPS novum

Very similar to the genus *Doliops* Waterh. Front of head without longitudinal grooves or callosity medially; eye kidney-shaped, surrounding the antennal base on three sides. First joint of the antenna moderately thickened, smooth, slightly conical, second joint very short; the two together somewhat shorter than the third joint and about as long as the fourth. Prothorax barrel-shaped, a third broader than long, the sides slightly bulging. Femora very pronouncedly club-shaped.

Type.—Pseudodoliops schwarzeri sp. nov.

PSEUDODOLIOPS SCHWARZERI sp. nov. Plate 1, fig. 8.

Black with white tomentose markings. Head with a tomentose stripe extending from the front to the vertex, sides also white tomentose. Anterior half of the third and fourth joints of the antenna gray-white tomentose. Prothorax finely and moderately densely black tomentose, with a groove parallel to the anterior margin and two grooves parallel to the posterior margin. The space between the anterior margin and the inner posterior margin pronouncedly scattered-punctate. Sides with a large, roundish, partly interrupted, white ringband. Scutellum white tomentose, elytra irregularly striate-punctate, punctuation next to the base coarse, dense and rasplike granulate. Each elytron in the basal third with a broader, somewhat curved, white transverse band extending from the lateral margin to near the suture, and with a narrower crossband in the apical third. Apical triangle with an irregular, oblong spot. Tibiæ in the apical half black setose, especially markedly so at the outer margin.

Length, 10 mm; shoulder breadth, 4.

MINDANAO, Zamboanga Province, Zamboanga.

I have named this species in honor of the recently deceased cerambycid specialist Herrn Bernh. Schwarzer, Schweinsheim.

CURCULIONIDÆ

PACHYRRHYNCHUS MONILIFER STELLULIFER[3] var. NEOJUGIFER var. nov.

This variety strongly resembles *P. jugifer* Waterh., especially in the elytral markings. Ground coloring glossy blue-black. Scale markings pale greenish, cream-colored, or pale pink. Prothorax with an arrow-shaped longitudinal stripe on the disk extending forward two-thirds of its length from the base; on either side of the anterior margin a small crescent-shaped scale spot and on the sides over the anterior coxæ a longitudinal stripe. Elytra, with exception of the following bare spots, completely scaled. A large oval sutural spot in the basal half, and an oblong triangular sutural spot extending from behind the middle to the apex. Besides, in the apical half of each elytron a more or less markedly reduced triangular bare spot. The sutural spots are medially more or less connected with each other.

---

[3] Schultze, Philip. Journ. Sci. 23 (1923) 645, pl. 5, figs. 14 and 18.

MINDORO, Puerto Galera, 3 specimens.

PACHYRRHYNCHUS RIZALI sp. nov. Plate 1, fig. 17.

Metallic, coppery red shining with pale green scale spots. Rostrum, the apical half swollen, the basal half with a shallow impression and a triangular scale spot cut in two by a fine mesal groove; a small scale swarm below the eyes. Prothorax subglobular, smooth, with a faint anteromarginal groove and a more pronounced posterior marginal groove. Dorsally in the middle, on the anterior margin and on the posterior margin, two triangular rounded scale spots, on either side medially between the anterior and posterior margins, a larger oval spot, and laterally above the fore coxæ a broader irregular scale stripe. Elytra with sharply pronounced striæ which become more pronounced laterad. Each elytron with eleven more or less oval or roundish spots forming three irregular transverse rows, as well as two sutural spots common to both elytra. The basal transverse row consists of three spots, of which the one lying between the second and third puncture rows is oblong-oval, the medial one is smallest and round, the third is large and elongate, lying some distance from the lateral margin. The second or medial transverse row consists of four spots of which three are roundish, the fourth spot, being the largest on the elytron, is elongate and located at the lateral margin. The third transverse row consists of three spots of which that lying near the suture is larger and oval. In the apical triangle is another, larger, triangular spot. Of the two sutural spots one is between the second and third transverse rows and the other next to the apex. Undersides of the prothorax and of the mesothorax scaled, the metathorax only laterally. Terminal abdominal segment smooth medially, depressed and rugose-punctate laterally, on either side with a scale spot. Femora with a spot ventrally next to the apex.

Male, length, 12.6 mm; width, 6.

Female, length, 12 mm; width, 6.

LUZON, Tayabas Province, Casiguran: Nueva Vizcaya Province, Mount Dibago.

This species is related to the species of my group VI[4]—namely, *P. multipunctatus* Waterh. *pseudoproteus* Schultze, and *elegans* Waterh., but may be distinguished from the latter especially by the peculiar markings of its prothorax. In the old specimens the ground color is black. I name this species in honor of the Philippine patriot José Rizal. Collected with *P. rizali* on the same bushes was a *Metapocyrtus* species which has a mimicry relationship to the former.

PACHYRRHYNCHUS BUCASANUS[5] subsp. ORNATUS subsp. nov.

Glossy dark green with pale yellow-green scale spots which are larger than those on the type species. Prothorax with spots as in the typical form, but without scale stripes at the anterior and posterior margins. Each elytron with eight to nine spots, in two specimens a third, very small spot between the two spots in the second transverse row. The third transverse row, which in each elytron of the typical form has four spots, consists, in the case of these three specimens (four are before me) of *ornatus* of only three spots.

SAMAR, Borongan.

Together with the above species was collected another species of the cerambycid genus *Doliops*, which stands in a mimicry relationship to *P. bucasanus ornatus*.

PACHYRRHYNCHUS GALERAENSIS sp. nov.

Related to *P. erichsoni* Waterh. Head, prothorax, and legs glossy metallic dark blue, elytra dully black, scale spots pale reddish pink. Rostrum in the apical half much swollen, depressed medially and from there to the front with a very pronounced medial groove, under the eye a scale spot. Prothorax subglobular, with a round scale spot mesally on either side and a very large spot above the fore coxæ. Elytra with pronounced puncture rows. Each elytron with eleven scale spots forming three transverse rows. The basal transverse row consists of three spots of which the mesal one is very small and round, the others are large and oblong oval; the mesal transverse row also consists of three spots, of which the medial one is the smallest; the third transverse row consists of four spots, the spot lying between the fourth and fifth puncture row being the smallest; in the apical triangle is another, larger, triangular spot. Meso- and metathorax each with a scale spot laterally.

---

[4] Philip. Journ. Sci. 24 (1924) 316.

[5] Deutsche Ent. Zeitschr. (1922) 40, pl. 1, fig. 11, female; Philip. Journ. Sci. 23 (1923) 665, pl. 2, fig. 1; pl. 5, fig. 10.

Female, length, 13.7 mm; width, 6.6.

MINDORO, Puerto Galera.

PACHYRRHYNCHUS DAVAOENSIS sp. nov.

Related to *P. speciosus* Waterh. and *postpubescens* Schultze. Brightly shining metallic coppery with cream-colored scale markings. Rostrum with a triangular depression, front of head with a wedge-shaped scale spot. Prothorax smooth, with a longitudinal stripe on the disk, extending from the base to near the anterior margin, sides with a large ring-shaped scale spot. Elytra with fine but sharply marked puncture rows. Each elytron at the base with a large irregularly oval ring-shaped spot similar to that in *P. speciosus* Waterh.,[6] mesally with two subparallel transverse lines confluent, however, along the suture instead of crossing it as in *P. speciosus* and *postpubescens*. These two transverse lines are confluent also at the lateral margin and continuing circumscribe in the apical part of each elytron a triangular figure, again similar to that in *speciosus*. Underside of prothorax and of mesothorax also scaled, metathorax and first abdominal segment laterally with a scale spot. Femora each with a small scale spot below near the apex.

Male, length, 13.6 mm; width, 6.

MINDANAO, Davao Province, Apo Volcano, altitude 2,000 meters (*J. Clemens*).

PACHYRRHYNCHUS REGIUS[7] var. BORONGANUS var. nov.

On the prothorax, discally, the arrow-shaped marking of the type is very much broadened in this variation. The ring-shaped markings of the elytra are smaller, and the large basal ring spot in var. *boronganus* is oblong oval.

SAMAR, Borongan.

The note of Heller[8] is erroneous in so far as it concerns *P. regius* Schultze from Leyte Island; what is meant is probably the above variation from Samar Island.

---

[6] Philip. Journ. Sci. 23 (1923) 657, pl. 2, fig. 23.

[7] Philip. Journ. Sci. 21 (1922) 579, pl. 2, fig. 6, female; 23 (1923) 657, pl. 2, fig. 25; pl. 9, fig. 14.

[8] Wien. Ent. Zeitg. 41 (1924) 172.

MACROCYRTUS (s. str.) TRILINEATUS sp. nov. Plate 1, fig. 2.

Dark brown with pale green scale markings. Head, rostrum irregularly scattered-punctate with a shallow, flat impression and a fine medial groove, the punctation diminishing on the front, the latter with a few scattered scales. Prothorax finely and irregularly scattered-punctate, on the disk with an oblong not sharply delimited scale spot, on either side a broad longitudinal scale stripe which is interrupted before the middle, and over the fore coxæ an irregular scale spot. Elytra very minutely coriaceously rugose with indistinct puncture rows. Each elytron between the second and third rows with a longitudinal scale stripe extending from the base to the apex, medially this stripe is spotlike expanded by means of an oblong scale swarm. A further stripe, laterally, next to the lateral elytral slope, which, however, is interrupted, and forms in the basal half two large oblong spots, and in the apical half two small fragmentary spots. A further scale stripe at the lateral margin, interrupted mesally. Mesothorax and metathorax on either side with an irregular scale spot. Inner margin of the hind tibia armed with four blunt teeth.

Male, length, 16 mm; width, 6.3.

LUZON, Benguet Subprovince, Irisan (*W. Schultze*).

In general form this species resembles most *M. contractus* Chevr. (=*nigrans* Pasc.).

APOCYRTUS CHAPMANI sp. nov. Plate 1, fig. 14, female.

Black with light greenish or bluish scale spots. Rostrum minutely scattered-punctate, vaulted laterally, with a faintly marked mesolongitudinal groove divided from the front by a deep transverse groove. Front scatteredly punctate and scaled, with a sharply outlined mesal groove. Prothorax subglobular, very coarsely and evenly rounded-granulate at the anterior margin, delimited by an indistinct shallow constriction, smooth. Disk with a fine mesolongitudinal groove and narrow scale stripes. Prothorax laterally scatteredly scaled, but over the fore coxæ with a large spotlike scale swarm. Elytra resembling most in form *A. mcgregori* Schultze, very pronouncedly and remotely striate-punctate with oblong scale spots partially arranged in three transverse rows. Each elytron at the base with three irregular scale spots, four further ones before the middle and three others behind the middle; besides, in the apical fourth, a large triangular spot connected at the outer margin to a scale stripe extending to the base. Between the third transverse row and the apical spot is also a small sutural spot. The above-mentioned spots have the tendency to unite into rudimentary longitudinal stripes. Mesosternum and metasternum laterally scaled.

Male, length, 10.2 mm; width, 4.5.

Female, length, 11.3 mm; width, 5.6.

NEGROS, Oriental Negros, Cuernos Mountains (*J. W. Chapman*).

I dedicate this interesting species to its discoverer, Dr. J. W. Chapman, enthusiastic myrmecologist of Silliman Institute.

PROAPOCYRTUS LUZONICUS sp. nov. Plate 1, fig. 13.

Black, elytra with the exception of the lateral margins, and femora with the exception of the apical parts, and tibia, red-brown. Rostrum minutely scatteredly punctate, at the base divided from the front by a pronounced transverse groove, in the basal part with a fine mesolongitudinal groove crossing the transverse groove and continuing on the front. The latter also minutely scatteredly punctate. Sides of head with several scattered pale green scales. Prothorax subcylindrical, as long as broad, evenly, densely, but shallowly and roundly, coriaceously granulate, the granulation somewhat more minute than in *P. insularis* Schultze;[9] side above the fore coxæ with a large spotlike scale swarm. Elytra dorsally flat and uniformly bulging, laterally from the base to the middle pronouncedly divergingly bulging, in the apical fourth laterally compressed so that the latter forms a beak-shaped projection. Elytra very coarsely striate-punctate, the punctures confused laterad. Along the lateral margins several small groups of pale green scales. Meso- and metathorax as well as first abdominal segment on either side with a pale-green scale swarm.

Male, length, without rostrum, 12.5 mm; width, 5.8.

LUZON, Rizal Province, Mount Irid.

METAPOCYRTUS (SPHENOMORPHOIDEA) CASIGURANUS sp. nov. Plate 1, fig. 16, female; Plate 2, fig. 26, male; 27, female.

Metallic coppery red shining; elytra with violet sheen and pale green scale markings. Rostrum minutely scatteredly punctate, constricted in the basal half, with a strongly pronounced mesal groove, which in the male ends at the base, and in the female extends to the front of head. Prothorax somewhat longer than broad, smooth, with scale stripes at the anterior and posterior margins as well as a spotlike stripe laterally above the fore coxæ; in the male these markings are reduced and less clearly defined. Elytra irregularly striate-punctate. Elytron in the female with two basal oblong-oval scale spots, and between these a shortened longitudinal stripe extending to the second transverse row of spots. The second tranverse row consists of a larger transverse spot on the disk and four additional spots, of which the third, lying near the lateral margin, is larger and wedge-shaped. The third transverse row consists of five spots of which that lying at the lateral margin is very elongate and stripelike. Next to the apex is a larger transverse spot, and in the apical third a sutural spot common to both elytra. In the male the elytral markings are also strongly reduced, in part only fragmentary, the shortened longitudinal stripe in the basal half is absent. Underside of prothorax and mesothorax laterally scaled.

---

[9] Philip. Journ. Sci. § D 13 (1918) 371, pl. 1, fig. 1.

Male, length, 7.8 mm; width, 3.

Female, length, 10.5 mm; width, 5.

LUZON, Tayabas Province, Casiguran.

This species was collected from the same shrubs as *Pachyrrhynchus rizali* sp. nov., which it superficially resembles.

METAPOCYRTUS (SCLEROCYRTUS) HERREI sp. nov. Plate 2, fig. 18.

Glossy black, covered with pink scale-swarms. Related to *M. celestinoi* Schultze and *chamissoi* Schultze. Rostrum as long as broad, basal half diverging anteriorly, dorsally curved and densely scattered-punctate, with a mesal groove which in the form of a pitlike depression extends to the sharply defined basal transverse groove and then continues on the front. Sides of head with a sickle-shaped scale spot. Front with a larger irregular scale swarm. Prothorax somewhat broader than long, the greatest width at the posterior margin, with shining irregular callosities which laterally disintegrate to tuberclelike eroded elevations. The depressed intervals filled with scale swarms, which are very dense laterally. The sculpture of the elytra similar to that of the prothorax, but the tuberclelike elevations more pronounced and arranged more in a longitudinal striate manner. Each elevation bears a short white hair. The depressed intervals beset with scale swarms, which toward the lateral margins are extremely crowded. Legs beset with fine white hairs.

Female, length, 10.7 mm; width, 5.

SAMAR, Burgos (*A. W. Herre*).

Metapocyrtus herrei may be easily distinguished from the above-mentioned related species by the absence of band markings. I dedicate this species to my friend and former colleague Dr. A. W. Herre, formerly ichthyologist in the Bureau of Science, Manila.

METAPOCYRTUS (ORTHOCYRTUS) DIBAGONUS sp. nov. Plate 2, fig. 12, male; 13, female.

Closest to *M. tumoridorsum* Chevr., although the form of the elytra in the female is shorter and more compressed-ovate. Black with sparse pale greenish white scaling. Rostrum densely scatteredly punctate, and minutely setose, in the basal half with two diverging longitudinal callosities and a mesal depression. Front more coarsely scatteredly punctate, sparsely pubescent, with a fine mesal groove. Prothorax pronounced scarred-punctate and coriaceously rugose; sculpture coarser than in *M. tumoridorsum* Chevr.; several scattered scales only laterally above the fore coxæ. Elytra fairly evenly scatteredly scarred-punctate. From each puncture emerges a short white hair, the pubescence in the apical part somewhat longer. In the female the scaling forms indistinct transverse bands, basally and medially; in the male it is much scattered. The mammælike elongation in the female is less marked than in the above species. The short and compressed form of the elytra of *M. dibagonus* also suggests *M. brevicollis* Chevr.

Male, length, 9.6 mm; width, 4.

Female, length, 10 mm; width, 4.5.

LUZON, Nueva Vizcaya Province, Mount Dibago and Mount Alzapan.

METAPOCYRTUS (ORTHOCYRTUS) PROLONGATUS sp. nov. Plate 2, fig. 16, female; 17, male.

Related to *M. tumoridorsum*[10] Chevr. Black with more or less dense scattered greenish white scales. Rostrum intricate and densely rugose-punctate, sparsely white pubescent, with a shallow longitudinal pit beset with a scale swarm. Rostrum divided from the front by a straight transverse groove. The latter scatteredly punctate and scatteredly scaled, with a very fine mesal groove. Sides of head more densely white pubescent. Prothorax in the male relatively larger than in the female, evenly densely rugose-punctate, moderately densely scatteredly scaled and beset with extremely fine white hairs. On the disk with an indistinct, in the male narrow, in the female broader, smooth longitudinal median callosity. Elytra in the male densely punctate and coriaceously rugose; in the female remotely scatteredly scarred and indistinct striate-punctate, the rugosity only faintly marked. Form of elytra in the male normally ovate, in the female mammælike elongated in the apical part, from there sloping abruptly to the apex. In both sexes the apical part of the elytra toward the lateral margins beset with fine, moderately long, white hairs. Mesosternum and metasternum in the male densely white pubescent, in the female more faintly so.

---

[10] Chevrolat, Le Natur. (1881) 382; Schultze, Philip. Journ. Sci. 26 (1925) 180, pl. 2, fig. 17, female.

Male, length, 11.5 mm; width, 5.

Female, length, 12.6 mm; width, 5.5.

LUZON, Laguna Province, Mount Banahao (*W. Schultze*).

The female of *M. prolongatus* sp. nov. may be distinguished from that of *M. tumoridorsum* Chevr. especially by the more elongate form, the fainter sculpture, and the pubescence of the prothorax as well as of the elytra. In *M. tumoridorsum* the scaling of the prothorax is sparser, that of the elytra in the basal part more marked. Furthermore, the form of the elongation of the elytra in the latter species is more dual, in *prolongatus* evenly rounded mammælike elongated. Unfortunately, I have before me only four females of *M. tumoridorsum* Chevr.; namely, one specimen (ex coll. Faust) from the Dresden Museum, without a definite locality, and three from Mount Moises, Isabela Province, Luzon.

METAPOCYRTUS (ORTHOCYRTUS) TUMOROSUS sp. nov. Plate 2, fig. 14, male; 15, female.

Related to *M. tumoridorsum* Chevr., but immediately distinguishable, especially the female, from that species, by the broader, laterally more pronouncedly distended, dorsally somewhat flattened prothorax, similar to *M. brevicollis* Chevr. Rostrum densely and evenly rugose-punctate with pronounced mesal longitudinal groove scatteredly scaled. Front more minutely rugoso scatteredly punctate with a fine mesal groove. Sides of head with a swarm of oblong, pale greenish white scales. Prothorax moderately pronounced evenly coriaceously rugose and scatteredly scaled. Elytra intricate and indistinct striate-punctate, in the male the indistinct interstices somewhat more longitudinally, callositylike raised; scaling indistinct longitudinally striate. In the female the tumorlike or mammælike projection at the apical sutural slope laterally somewhat compressed, appearing slightly dually rounded. The apical slope similar to *M. prolongatus* Schultze. Apical part of the elytra, especially the sutural slope, beset with longish white hairs.

Male, length, 11 mm; width, 4.8.

Female, length, 11.2 mm; width, 5.5.

LUZON, Rizal Province, Mount Irid.

METAPOCYRTUS (ORTHOCYRTUS) MUMUNGANUS sp. nov. Plate 2, fig. 19, male; 20, female.

Related to *M. virens* Heller. Black with metallic golden or greenish bronze scale markings. Rostrum irregularly scatteredly punctate, with two longitudinal callosities diverging anteriorly and a scaled mediolongitudinal groove. Rostrum divided from the entirely golden scaled front by a deeply marked V-shaped basal-transverse groove. Sides of head also scaled. Prothorax subglobular, next to the base laterally slightly constricted, coarsely flattened granulate; sculpture in the female more faintly outlined. Discal part, with the exception of a narrow longitudinal medial bare stripe, densely scaled between the granulations. A narrow scale stripe at the anterior margin unites on the sides with a large, sharply delimited transverse spot. Elytra strongly but rather irregularly double striate-punctate, with a broad scaled crossband at the base and before the middle, as well as a very large scale spot in the apical third. The bands, as well as the spot, do not cross the suture, but extend only to the second or first puncture row of each elytron. In the female, apical third of the suture with several sharp setæ surrounded by several scales. Apical part of the femora as well as the external side of the tibia with golden scales. Meso- and metathorax laterally also with golden scales.

Male, length, 8.4 mm; width, 4.

Female, length, 9.5 mm; width, 4.7.

MINDANAO, Lanao Province, Mumungan.

METAPOCYRTUS REYESI[11] **DACONUS** subsp. nov.

Black, with reddish golden scale markings in position as in the type. The sculpture very similar to that of the latter but more faintly pronounced.

NEGROS, Oriental Negros, Lake Daco (*J. W. Chapman*).

---

[11] Schultze, Philip. Journ. Sci. 26 (1925) 198, pl. 5, fig. 25, male; 26, female; pl. 12, fig. 10.

The above local race of *M. reyesi* is in appearance very similar to *Pachyrrhynchus negrosensis* Schultze and stands in a mimicry relationship to this species.

METAPOCYRTUS (METAPOCYRTUS) IRIDANUS sp. nov. Plate 2, fig. 10, male; 11, female.

Black with light blue scale spots; related to *M. gibbirostris* Waterh. Rostrum in the male dorsally flat with a shallow impression, minutely scatteredly punctate, divided from the front by a fine transverse groove. The impression with a small scale spot and a small spot at the transverse furrow. Back of rostrum in the female markedly inflated, slightly concave with a longitudinal groove in the basal half; the swelling ends in a blunt tubercle-shaped hump at the base, terraced off from the front; the latter in the male finely and sparsely scattered-punctate with a short mesal groove; in the female, scarred punctate with a long mesal groove. Sides of head with a scale swarm. Prothorax broader than long, the sides evenly rounded, markedly and uniformly coriaceously shagreened, this sculpture coarser in the female and more irregularly outlined. The scale markings consist of an anteromarginal stripe, which on the sides above the fore coxæ expands spotlike and extends to the posterior margin; on either side of the middle, next to the posterior margin, a larger roundish spot. Elytra with marked, somewhat irregular, longitudinal double puncture rows. Each elytron with three transverse rows of roundish or oval scale spots, which are laterally more or less confluent. The first or basal transverse row consists of two spots of which a larger oval lines between the first and third spatia, the other, placed more laterally, is more or less united with a lateromarginal stripe, extending to the apical fourth. The second or third transverse row consists of three spots of which that lying on the disk is roundish, and the other two, more lateral, are more or less crossbandlike confluent with the lateromarginal stripe. In the third transverse row, in the apical third, the external spot is also united with the lateromarginal stripe. Next to the apex is another spot besides the one mentioned above. Posterior elytral slope in both sexes uniformly rounded, female in the apical part with several long white hairs. Legs uniformly white pubescent.

Male, length, 11 mm; width, 4.3.

Female, length, 11 mm; width, 5.

LUZON, Rizal Province, Mount Irid.

METAPOCYRTUS (METAPOCYRTUS) SUBPILOSUS sp. nov. Plate 2, fig. 9, female.

Related to *M. pilosus* Schultze.[12] Black with sparse pale green scaling. Rostrum rugose-punctate, with indistinct longitudinal groove continuing on the front. The latter scatteredly punctate, and, like the rostrum, finely pubescent. Prothorax subglobular, relatively much smaller, in both sexes, than in *M. pilosus* Schultze; uniformly coriaceously rugose-punctate, the sculpture finer than in the above species, with a few scattered scales next to the anterior and posterior margins and on the sides. The gray pubescence very similar to that of *M. pilosus* Schultze, only somewhat finer and longer. Elytra fairly regularly striate-punctate, suture at the base, especially in the female, markedly inflated; the interstices slightly moldinglike raised and faintly rugose, more pronounced in the female. From each puncture emerges a short hair, finer than in the above species. In the female at the posterior sutural slope a slight swelling, beset with a tuft of longish hairs. Elytra with more or less scattered scales on the sides, forming in the female a very indistinct basal, median, and ante-median crossband.

Male, length, 10 mm; width, 4.

Female, length, 10 mm; width, 4.6.

LUZON, Rizal Province, Mount Irid.

METAPOCYRTUS (DOLICHOCEPHALOCYRTUS) DUYAGI sp. nov. Plate 2, fig. 1, male; 2, female.

Black with sparsely scattered pale bluish or greenish scales. Related to *M. frosti* Schultze and to *M. elicañoi* Schultze, although closer to the latter species. In the male, rostrum with the mesal longitudinal groove more pronounced than in *M. elicañoi*, before the basal transverse groove on either side swollen, sides before the eye with an oblong triangular pronounced depression; in the female, rostrum in the basal part humplike rounded swollen, also more pronounced than in the above species. Prothorax in both sexes uniformly flattened granulate, the granulation coarser and more flattened than in the above species, and with very fine short white hairs between the granulations. Elytra moderately, densely and irregularly striate-punctate and slightly rugose, from each puncture emerges a fine short hair. Apical elytral slope of the female less abrupt than in *M. elicañoi*.

---

[12] Philip. Journ. Sci. 26 (1925) 195, pl. 11, figs. 21, 22.

Male, length, 10.4 mm; width, 4.4.

Female, length, 10.5 mm; width, 4.6.

LUZON, Rizal Province, Mount Irid.

METAPOCYRTUS (TRACHYCYRTUS) SUBSPINIPES sp. nov. Plate 2, fig. 7, male; 8, female.

Related to *M. spinipes* Chevr., and very similar to the latter in scale markings, more elongate in the elytra. Elytra black and legs dark brown. Rostrum densely intricately rugose punctate, with an indistinct longitudinal depression, divided from front by a marked basal transverse groove. Front more sparsely punctate, with a fine longitudinal groove. Rostrum as well as front remotely though evenly beset with fine white hairs which are directed toward the longitudinal middle. Prothorax very evenly rounded granulate, between the granulations remotely beset with fine white hairs, sides with a few scattered pale greenish white scales. Elytra with tuberclelike or slightly rasplike sculpture coarser than in *M. spinipes* Chevr. and beset with fine hairs, which in the last-mentioned species are much finer and sparser. Each elytron with a greenish white scale crossband at the base, triangularly expanded toward the lateral margin, and an irregular scale swarm medially on the elytra, at the lateral margin. In the female the posterior elytral slope at the suture slightly humplike swollen and beset with short robust setæ. Underside and legs also beset with whitish hairs, which are somewhat longer than those of the elytra.

Male, length, 9.8 mm; width, 4.

Female, length, 11 mm; width, 4.6.

LUZON, Cagayan Province, Peñablanca.

METAPOCYRTUS (TRACHYCYRTUS) MULTIMACULATUS sp. nov. Plate 2, fig. 25, female.

Black with pale bronze green scale spots and on account of the markings similar to *M. calavitensis* Schultze in appearance, but immediately distinguishable from the latter by the difference in form and sculpture. Rostrum diverging anteriorly, minutely intricately scatteredly punctate with two more strongly diverging longitudinal callosities which at the base slope off laterally. Between the callosities a slight depression with several scales. Front divided by a deeply marked basal transverse groove, with an indistinct mesal groove densely scaled. Prothorax coarsely and densely flattened granulate with a slight mesal groove, the granulation on the sides finer, more remote, and more rasplike granulate. At the anterior margin an irregular scale stripe which continues to the posterior margin over the fore coxæ, and laterally from the middle ends as a shortened longitudinal stripe. Elytra coarsely and irregularly striate-punctate with a scale stripe at the outer margin spotlike expanded at the base; a basal spot, with two further spots before the middle and in the apical third, respectively, forming a transverse row, and an oblong spot in the apical triangle. Posterior elytral slope along the suture with a double row of short black setæ, more faintly outlined in the male. Apical third of the femora above with an oblong scale spot.

Male, length, 9.5 mm; width, 3.

Female, length, 10 mm; width, 4.2.

LUZON, Isabela Province, Mount Moises.

METAPOCYRTUS (TRACHYCYRTUS) TRISTIS sp. nov. Plate 2, fig. 3, male; 4, female.

Related to *M. turgidofemoralis* Schultze and like it of elongate form. Black with cream-colored or pale greenish scattered scaling, and fine, uniform, moderately dense, short gray pubescence. Rostrum finely and densely intricately punctate with two not sharply outlined longitudinal callosities and a dimple which is longer in the male and shorter in the female. Sides of rostrum before the eyes with a deep practically triangular impression. Front divided from the rostrum by a sharply pronounced basal transverse furrow, scattered-punctate and with a fine mesolongitudinal groove. Prothorax pronouncedly and uniformly coriaceously rugose, with sparse scattered scaling, which on the sides becomes denser and more even. Elytra oblong oval, intricately and faintly rugose striate-punctate, in the male less dense and more finely scaled, in the female dense and coarsely scaled. The fine pubescence shorter than that of the prothorax. Elytra in the female at the apical sutural slope with a dual wartlike protuberance, then the suture falling off abruptly and slightly concavely to the apex, the apical part of the elytra longer pubescent and reduced to a blunt point. Posterior elytral slope in the male normally rounded.

Male, length, 9 mm; width, 3.3.

Female, length, 10.2 mm; width, 3.8.

LUZON, Nueva Vizcaya Province, Balete Pass (*W. Schultze*).

METAPOCYRTUS (TRACHYCYRTUS) CORPULENTUS sp. nov. Plate 2, fig. 5, female.

Black with cream-colored scale markings, in the female the elytra of very short compressed-ovate form. Rostrum minutely scattered-punctate, slightly swollen, with two longitudinal callosities converging toward the basal transverse groove, and a longitudinal impression on either side between the callosity and the lateral margin. Front minutely and densely rugose punctate with a fine median furrow. Prothorax very uniformly coarsely granulate, between the granulations sparsely, on the sides more densely, scaled. Elytra faintly rugose granulate, the granulation toward the sides more pronounced and more pointed-granulate outlined, with three irregular scale crossbands confluent along the lateral margins. In the female, at the beginning of the apical sutural slope with a tuberclelike swelling beset with a dual tuft of pale reddish hair. Sutural slope falling off vertically to the apex.

Female, length, 8 mm; width, 4.

NEGROS, Occidental Negros, Fabrica (*W. Schultze*).

A somewhat isolated species.

METAPOCYRTUS (TRACHYCYRTUS) PERARMATUS sp. nov. Plate 2, fig. 21, male; 22, female.

Related to *M. spinipennis* Schultze and *crassispinosus* Schultze. Black with remotely scattered white scaling. Rostrum minutely, densely and intricately punctate, in the male flattened with a small roundish dimple in the basal half, in the female toward the lateral margins more rounded, the rostrum constriction at the base diminishing laterally; above the antennal pit is an impression threaded by pronounced longitudinal rugosities. Front scattered punctate, sparsely beset with white hairs, and with a pronounced median furrow. Prothorax, in the male, broader than the elytra, uniformly densely rounded granulate, between the granulations—which in the male are coarser—scattered white scales and very fine white hairs. Elytra irregularly striate-punctate and faintly rugose with more regular, remotely scattered, white scales. In the female, the suture at the beginning of the apical elytral slope callously swollen and densely setose, but not forming protuberances as in *M. spinipennis* and *crassispinosus*. Apex of each elytron ending in a short compressed conical point. Between the points a triangular interval which is larger than the corresponding one of the female of the above-mentioned species. Elytra in the apical part, in both sexes, beset with rather long scattered hairs.

Male, length, without rostrum, 8.3 mm; width, 3.5.

Female, length, 10.4 mm; width, 4.5.

PANAON ISLAND, south of Leyte (*G. Böttcher*).

The above species was obtained through the kindness of Hofrat Prof. Heller, who proposed the name given above.

METAPOCYRTUS (TRACHYCYRTUS) ALABATANUS sp. nov. Plate 2, fig. 23, male; 24, female.

Closely related to *M. macrospinosus* Schultze. Black with golden scaled crossbands. Rostrum in the male somewhat longer than in the female, densely and irregularly punctate, constricted at the base, with a longitudinal impression which is somewhat shortened in the female. Front scattered punctate with a sharply outlined mesal groove. Prothorax densely flattened granulate, as in *M. macrospinosus*, but the sculpture more flattened and somewhat more irregular. At the anterior and posterior margins a crossbandlike, more or less dense scale swarm, which is confluent on the sides. Sculpture of the elytra also similar to that in the above species, but less marked; each elytron with three scale crossbands, basally, medially, and next to the apex. These bands are more or less confluent at the lateral margins. In the female, each elytron ending in a conical point, considerably shorter than in the above species; the points of both elytra are pressed against each other and form a triangular continuation, whereas in *M. macrospinosus* they diverge in the last third of their length.

Male, length, without rostrum, 8.4 mm; width, 3.3.

Female, length, 9 mm; width, 3.8.

ALABAT ISLAND, a part of Tayabas Province.

In its scale markings this species resembles *M. acutispinosus* Schultze.

METAPOCYRTUS (TRACHYCYRTUS) BREVIARMATUS sp. nov. Plate 2, fig. 6, female.

Related to *M. acutispinosus* Schultze and resembling the latter in its scale markings. Black with metallic pale green scale bands. Rostrum densely scatteredly punctate, in the male with a barely suggested mesal groove, in the female uniformly vaulted without a longitudinal impression. Basal transverse groove deeply marked and ending on the sides in pointlike impressions. Prothorax with a sharply defined anteromarginal groove, pronouncedly flattened transverse rugose, in the male with an indistinct mesal groove. The scaling is more or less dense, crossbandlike at the anterior and next to the posterior margin and confluent on the sides. Elytra evenly striate-punctate, with three not very sharply delimited scale crossbands, which along the outer margin are more or less confluent, also similar to *M. alabatanus* Schultze. In the female the apical sutural slope with a small dual tuft of short cream-colored hair, each elytron ending in a short, compressed, conical, thornlike point. The points divergent and about one-third the size of those of *M. acutispinosus*. Apical elytral slope in the male normally vaulted; apex of the elytra rounded.

Male, length, 7.5 mm; width, 3.2.

Female, length, 9.5 mm; width, 4.

CATANDUANES ISLAND, Virac.

CELEBIA SAMARANA sp. nov. Plate 1, fig. 4.

Glossy black, with light bluish and pale greenish white opalesque scale markings. Rostrum dorsally smooth, only along the lateral margins scattered coarse punctures. Prothorax somewhat broader than long, along the middle on the disk smooth, only in the anterior half with a deep, rather coarse punctiform impression which diminishes into a very much shortened longitudinal groove. Laterally from the middle remotely scattered coarse punctuation and in between irregularly minutely punctate. Prothorax also laterally from the middle with a longitudinal not sharply delimited light bluish scale swarm, on the sides with a larger irregular pale greenish white scale spot and a further smaller spot above the fore coxæ. Scutellum round, knoblike raised, whitely scaled. Elytra striate-punctate, the punctures coarse and deep. Each elytron with two larger scale spots in the basal fourth, one lying between the second and fifth puncture rows, the other, somewhat smaller, along the lateral margin. In the apical half in the second spatium a longitudinal scale stripe extending to the apex, then bending and continuing anteriorly along the lateral margin to the second third of its length. Immediately before the beginning of the longitudinal stripe in the second spatium, and connected with the latter, a fairly large, irregular, and somewhat more posteriorly a small scale spot. Laterally from the former between the fifth and ninth puncture rows a further, larger, very irregular spot, and posteriorly a small, round, and in the apical triangle an irregular triangular spot, the latter confluent with the lateral marginal stripe. A small fragmentary spot antemedially in the eighth spatium. The entire underside more or less pronouncedly scaled. Tibia on the underside short, white setose.

Length, with rostrum, 18.5 mm; width of elytra, 7.6.

SAMAR, Borongan.

By its conspicuous markings this interesting species is easily distinguishable from the two other known Philippine species of this genus; namely, *C. merrilli* Schultze[13] and *iligana* Schultze.[14] With the last-mentioned species and *C. lactospreta* Heller[15] it forms another link in the chain of New Guinea-Molucca elements in the Philippine fauna.

COPTORHYNCHUS ORNATUS sp. nov. Plate 1, fig. 10.

Glossy black with white scale markings. Rostrum dorsally appearing longitudinally somewhat compressed on account of the large antennal scrobes. Along the lateral margins with a row of coarsely confluent punctures, mesally with a shallow groove. Rostrum divided from front by a V-shaped groove. On either side between this groove and the eyes a small triangular scale patch. Front scatteredly punctate. Prothorax somewhat longer than broad, the sides pronouncedly rounded; laterally, at the anterior margin slightly, at the posterior margin pronouncedly, constricted, flattened on the disk; extremely coarsely, evenly densely, and confluent punctate. On either side of the middle a short longitudinal stripe continuing on the anterior margin and then uniting as a stripe over the fore coxæ with a posteromarginal stripe, which again sends off two short branches on either side of the middle anteriorly. Elytra pronouncedly striate-punctate with netlike scale markings which on both elytra circumscribe about fifteen areas. Each elytron with three longitudinal stripes and lateromarginal stripe. The first longitudinal stripe along the suture, extending from the middle to the apex; the second, in the third spatium from the base to the first fourth; the third in the fifth spatium from the basal fourth to the lateral margin. The longitudinal stripes are united with each other by crossbands, which, however, are partially briefly interrupted or spotlike disintegrated. A crossband at the base, a second in the first fourth unites the short basal longitudinal stripe with the third and then runs to the lateromarginal stripe; a third crossband extends from the su-

---

[13] Philip. Journ. Sci. 15 (1919) 557, pl. 1, fig. 16.

[14] Deutsche Ent. Zeitschr. (1922) 44, pl. 2, fig. 5.

[15] Mem. della Ent. Italiana 3 (1924) 185.

tural stripe to the marginal stripe; a fourth crossband behind the middle, linearly unites the sutural stripe with the third longitudinal stripe, and then, after a slight curve, with the lateromarginal stripe; a fifth crossband, in the apical fourth, extends from the sutural stripe to the third longitudinal stripe. The underside of the prothorax and of the mesothorax also scaled, metathorax and first abdominal segment only laterally.

Length, without rostrum, 11 mm; width of elytra, 5.7.

LUZON, Camarines Norte Province, Paracale (*W. Schultze*).

Coptorhynchus ornatus is easily distinguishable from the other species of this genus by its peculiar scale markings, which very strongly suggest certain pachyrrhynchids.

ALCIDES DUYAGI sp. nov. Plate 1, fig. 11.

Body subcylindrical; related to *A. kalinganus* Schultze. Head, prothorax, and legs metallic shining, brownish bronze, elytra shiny green-bronze, with creamy white tomentose markings. Prothorax evenly densely punctate, on either side of the middle at the anterior margin on the shallow constriction a small roundish, and more laterally, a somewhat larger tomentose spot, at the posterior margin beginning laterally of the scutellum a toment stripe which expands a little toward the sides. Laterally above the fore coxæ a narrow longitudinal stripe. Elytra with very uniform puncture rows, the punctures oblong. Beginning at the scutellum and the suture, directed posteriorly, a narrow tomentose crossband, which, describing a smooth arc, extends to the lateral margin. Behind the middle a further narrow crossband extends laterally from the suture to the eighth puncture row, then bends and continues in the ninth interstice to near the apex, where it unites, in the third interstice, with a short longitudinal stripe.

Length, without rostrum, 11.8 mm; shoulder breadth, 4.9.

LUZON, Nueva Vizcaya Province, Santa Fé (*W. Schultze*).

I dedicate this beautiful species to Anacleto Duyag, who has been my collector for many years.

ALCIDES NEGROSENSIS sp. nov. Plate 1, fig. 15.

Related to *A. pectoralis* Boh., which it resembles very much in body form, but from which it is easily distinguishable by the markings. Black with pale yellow crossbands. The toment consists of very short hairs covered with a pollenlike substance. Rostrum in the apical half minutely and densely, toward the base coarsely and intricately, punctate. Front very densely punctate and with a dimplelike impression. Prothorax, with the exception of a narrow border along the anterior margin, extremely coarsely eroded granulate, with a narrow tomentose band in the shallow constriction near and along the anterior margin, and a further band along the hind margin. Both bands somewhat expanded laterally. Elytra with very pronounced groovelike puncture rows, the intervals rounded, pronouncedly moldinglike prominent. Each elytron medially with a crossband, extending from the second puncture row to the lateral margin and toward the latter wedgelike expanded. In the apical third on the third interstice a longitudinal stripe, which before the apex curves like a short hook anteriorly at the lateral margin. Underside almost entirely more or less markedly tomentose.

Length, without rostrum, 9.8 mm; shoulder breadth, 4.3.

NEGROS, Oriental Negros, Lake Daco.

ALCIDES SUBCUPRINUS sp. nov. Plate 1, fig. 9.

Related to *A. cuprinus* Heller[16] and *kalinganus* Schultze. Metallic coppery shining with cream-colored tomentose markings, in the female the ground coloring with a strongly iridescent violet shimmer. Prothorax densely and evenly punctate, at the anterior margin above the lateral constriction on either side an irregular round tomentose spot, a further crescent spot on either side at the posterior margin, and on the sides above the fore coxæ an irregular spot. Punctuation on the sides more coarse and intricate. Each elytron with nine sharply defined and very regular puncture rows. The individual punctiform impressions elongate, more resembling short dashes. Each elytron in the basal part with a tomentose band, which from the suture extends, circumscribing the scutellum, in the shape of a curve to the lateral margin, but is interrupted between the fourth and fifth puncture rows and thus forms two large transverse spots. A further crossband, curved somewhat forward, behind the middle, extending from the first to the ninth puncture rows; next to the apex a broad V-shaped tomentose spot. The underside of the prothorax and of the mesothorax tomentose, as well as the metathorax and abdominal segments, especially laterally.

Male, length, without rostrum, 13 mm; shoulder breadth, 5.2 mm.

Female, length, 12.7 mm; shoulder breadth, 5.3.

---

[16] Stett. Ent. Zeitung 78 (1917) 241. Of this species from an unknown locality, I have before me three specimens from Peñablanca, Cagayan Province, Luzon.

LUZON, Ilocos Norte Province, Mount Palimlim, 1 male; Bangui, 1 female.

ALCIDES LAGUNENSIS sp. nov. Plate 1, fig. 12.

Related to *A. semperi* Pascoe, which it resembles very much in bodily form. Metallic steel-blue with whitish tomentose spots consisting of fine hairs. Rostrum in the apical half very minutely scatteredly punctate, basal half densely and rugose confluent punctate with a shallow mesal groove, which projects to front in the form of a dimple. Prothorax irregularly, minutely, and scatteredly punctate. On either side of the middle and behind the lateral constriction next to the anterior margin with a spotlike expanded transverse band extending to the fore coxæ. A further tomentose spot on either side at the posterior margin and a small round tomentose spot medially above the scutellum. Elytra irregularly coriaceously rugose with fine sharp puncture rows. Each elytron with ten tomentose spots of which seven are irregularly confluent, forming two transverse bands, one basal and one behind the middle. The basal transverse band consists of four confluent spots, of which three form a row; the fourth, however, is confluent with the second anteriorly and extends to near the base. The second transverse row of three spots behind the middle is more uniform. A third transverse row in the apical third consists of two spots and at the apex is another small tomentose spot. Underside of prothorax tomentose, mesothorax and metathorax as well as abdominal segments laterally.

Length, without rostrum, 12 mm; shoulder breadth, 5.

LUZON, Laguna Province, Paete (*W. Schultze*).

ILLUSTRATIONS

PLATE 1

[Original crayon drawings by W. Schultze. All figures magnified 2 : 1.]

FIG. 1. *Acronia luzonica* sp. nov.
2. *Macrocyrtus trilineatus* sp. nov.
3. *Cylindrepomus sexlineatus* sp. nov.
4. *Celebia samarana* sp. nov.
5. *Niphonoclea ornata* sp. nov.
6. *Pseudabryna hieroglyphica* sp. nov.
7. *Proteuclea palawana* sp. nov.
8. *Pseudodoliops schwarzeri* gen. et sp. nov.
9. *Alcides subcuprinus* sp. nov.
10. *Coptorhynchus ornatus* sp. nov.
11. *Alcides duyagi* sp. nov.
12. *Alcides lagunensis* sp. nov.
13. *Proapocyrtus luzonicus* sp. nov.
14. *Apocyrtus chapmani* sp. nov.
15. *Alcides negrosensis* sp. nov.
16. *Metapocyrtus casiguranus* sp. nov.
17. *Pachyrrhynchus rizali* sp. nov.

PLATE 2

FIG. 1. *Metapocyrtus (Dolichocephalocyrtus) duyagi* sp. nov., male.
2. *Metapocyrtus (Dolichocephalocyrtus) duyagi* sp. nov., female.
3. *Metapocyrtus (Trachycyrtus) tristis* sp. nov., male.
4. *Metapocyrtus (Trachycyrtus) tristis* sp. nov., female.
5. *Metapocyrtus (Trachycyrtus) corpulentus* sp. nov., female.
6. *Metapocyrtus (Trachycyrtus) breviarmatus* sp. nov., female.
7. *Metapocyrtus (Trachycyrtus) subspinipes* sp. nov., male.
8. *Metapocyrtus (Trachycyrtus) subspinipes* sp. nov., female.
9. *Metapocyrtus (Metapocyrtus) subpilosus* sp. nov., female.
10. *Metapocyrtus (Metapocyrtus) iridanus* sp. nov., male.
11. *Metapocyrtus (Metapocyrtus) iridanus* sp. nov., female.
12. *Metapocyrtus (Orthocyrtus) dibagonus* sp. nov., male.
13. *Metapocyrtus (Orthocyrtus) dibagonus* sp. nov., female.
14. *Metapocyrtus (Orthocyrtus) tumorosus* sp. nov., male.
15. *Metapocyrtus (Orthocyrtus) tumorosus* sp. nov., female.
16. *Metapocyrtus (Orthocyrtus) prolongatus* sp. nov., female.
17. *Metapocyrtus (Orthocyrtus) prolongatus* sp. nov., male.
18. *Metapocyrtus (Sclerocyrtus) herrei* sp. nov., female.
19. *Metapocyrtus (Orthocyrtus) mumunganus* sp. nov., male.
20. *Metapocyrtus (Orthocyrtus) mumunganus* sp. nov., female.
21. *Metapocyrtus (Trachycyrtus) perarmatus* sp. nov., male.
22. *Metapocyrtus (Trachycyrtus) perarmatus* sp. nov., female.
23. *Metapocyrtus (Trachycyrtus) alabatanus* sp. nov., male.
24. *Metapocyrtus (Trachycyrtus) alabatanus* sp. nov., female.
25. *Metapocyrtus (Trachycyrtus) multimaculatus* sp. nov., female.
26. *Metapocyrtus (Sphenomorphoidea) casiguranus* sp. nov., male.
27. *Metapocyrtus (Sphenomorphoidea) casiguranus* sp. nov., female.

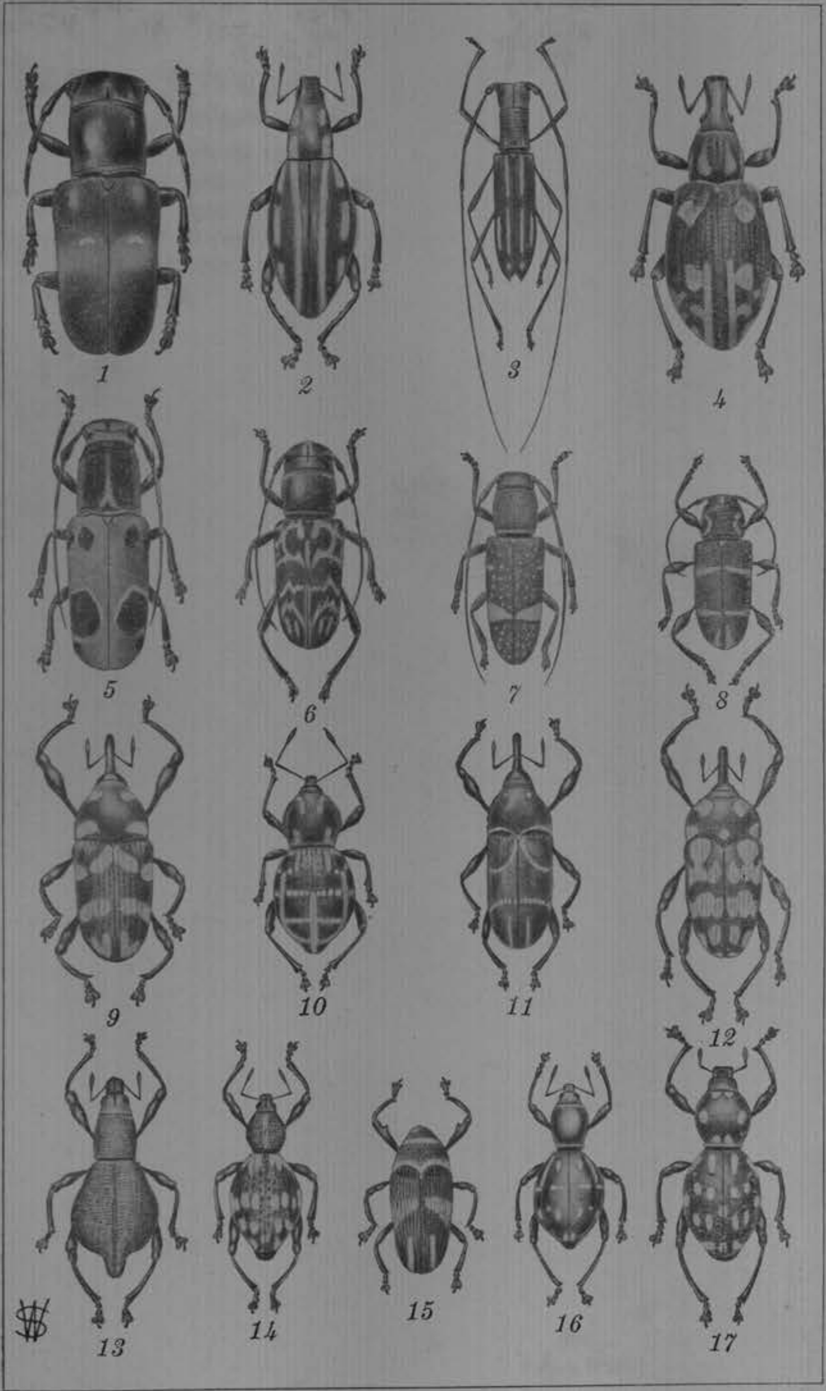


PLATE 1.

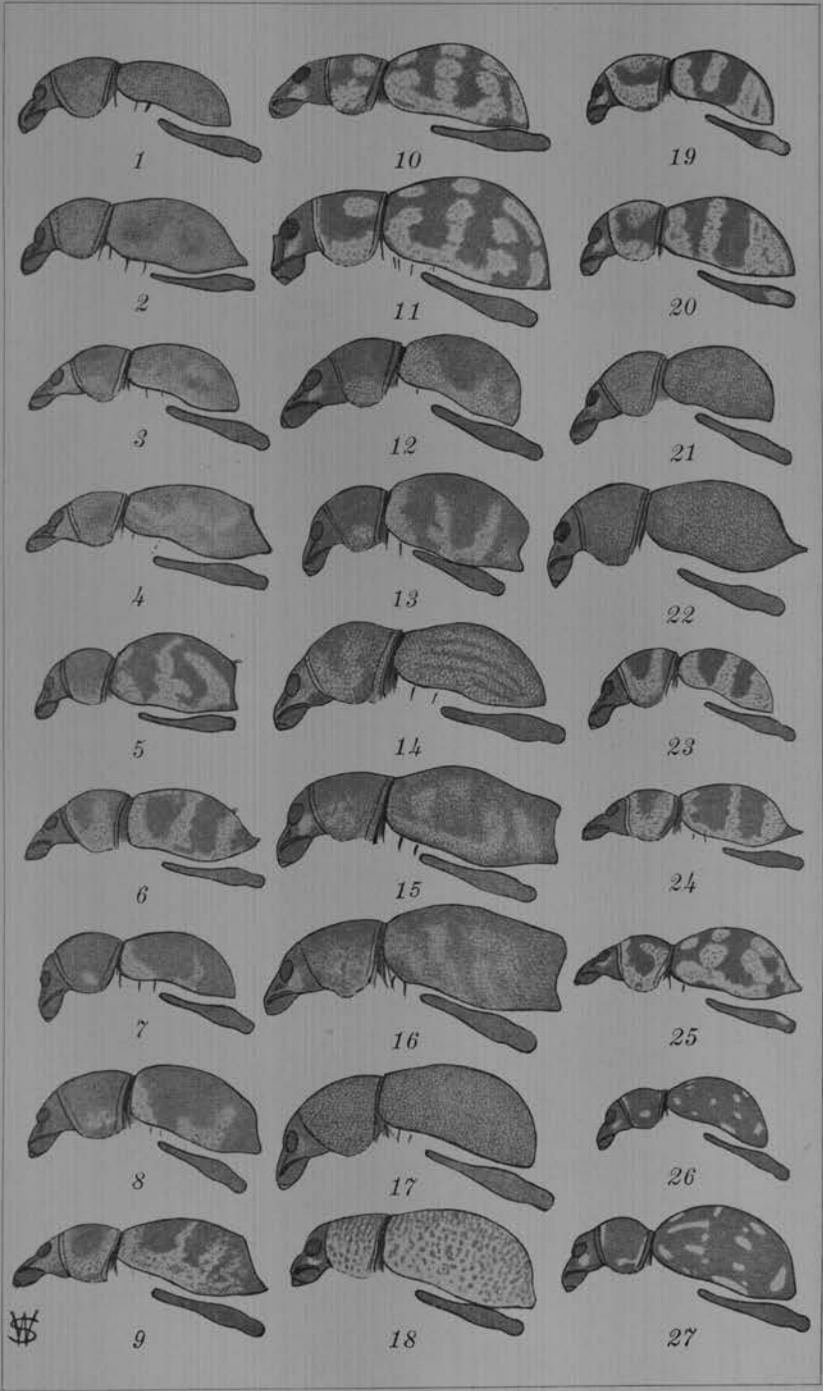


PLATE 2.

SOLAR ULTRAVIOLET RADIOMETRY

IV, THE ULTRAVIOLET OF SUNLIGHT IN MANILA[1]

By WM. D. FLEMING

Major, Medical Corps, United States Army; Member, United States Army Medical Department Research Board, Bureau of Science, Manila

The question of the suitability of the Tropics as a place of residence for members of the white race is of long standing, has many and varied aspects, and is still to be satisfactorily answered in perhaps any of these aspects. The military bearings of this question for any nation having troops on tropical duty are important and touch on such fundamentals as health, morale, ability to maneuver, and optimum length of tropical tour of duty. Many and most varied opinions have been, and are, held on all these bearings. In reviewing many of these opinions one cannot help but feel that personal prejudice and a great preponderance of subjective evidence, as opposed to objective evidence, have had disproportionate weight in their formation.

In no part of this question have these factors of prejudice and subjective evidence played a greater part than in the matter of the sunlight found in the Tropics. Woodruff's well-known book on Tropical Sunlight is an example of this. In the parts of this book in which the presence of any evidence can be detected, this evidence is wholly subjective.

On the other hand, the very few earlier reports on tropical sunlight available that do deal with objective evidence, are of work done with inadequate apparatus and, in some cases, do not meet the requirements of the present theory of radiation.

The present article records results of an attempt to obtain reliable objective evidence concerning certain fractions of the sunlight in one tropical locality.

The requirement of objectivity of the evidence has narrowed the scope of the investigation greatly. It is hoped that with this narrowing there has been a proportionate gain in reliability and pertinency. Such matters as the effects of this light on humans have necessarily been left untouched. It is fully realized,

---

[1] Submitted for publication March 9, 1933.

also, that the data deals with only one place, which may differ from other places in the Tropics in many respects. The extreme rarity of sunstroke in Manila in contrast with what is at least believed to be true of some other tropical localities may be cited as such a possible difference. With such aspects, only similar data obtained elsewhere both in the Tropics and in temperate climates can deal. Such work is slowly getting under way in several places in the world, and, in time, will doubtlessly afford an answer. It is desired to place this present work on record as a step in this program.

This report gives a quantitative spectral analysis of certain regions of the ultraviolet and violet of sunlight as found in Manila, P. I., over the period of one year, from February, 1932, to January, 1933, both inclusive. Values are reported in two different forms: as percentages of the total energy of the sunlight between the limits λ 290 and λ 1,400 millimicrons and in microwatts per square millimeter of surface normal to the incident light. The sunlight studied was divided into four different spectral bands as follows:

(*a*) 290 to 310 millimicrons
(*b*) 310 to 370 millimicrons
(*c*) 370 to 400 millimicrons
(*d*) 400 to 460 millimicrons.

The total solar energy was taken as lying between λ 290 and λ 1,400 millimicrons. The short wave-length limit is that usually assumed for sunlight. This was checked spectrographically in the course of this work as reported earlier.(1) The long wave-length limit of 1,400 millimicrons was taken as the limit of transmission of a layer of water 10 millimeters thick. This water filter was necessary to give a sharp upper cut-off to the various glass filters used.

PROCEDURE

The instruments and methods used have been reported in detail previously.(2) Briefly, the solar energy was measured by a thermopile and galvanometer. The energy fractions in the four spectral bands were determined by the decreased effect in this arrangement when glass filters of known transmission were placed over the thermopile, cutting off part of the energy.

LOCATION AND CLIMATIC CONDITIONS

Manila lies on the eastern shore of Manila Bay, on the west coast of Luzon, Philippine Islands, 120° 59′ east longitude, 14°

35′ north latitude. The instrumental observations were made on the roof of the building housing the Philippine Weather Bureau, over the third story. A clear view was had of all quarters of the sky.

The climate of Manila may usually be divided into three seasons: cool, hot, and rainy. The cool season usually extends from November through February with generally clear skies, the hot season from March to July with clear skies, and the rainy reason from July through October with very many cloudy days. In 1932, however, cloudy weather was the rule throughout what should have been the clear days of October, November, December, and in January, 1933. As was explained in the article on Instruments and Methods, work could be done only upon the clear sun entirely free from clouds, and when this condition of clearness lasted for at least fifteen minutes. Each individual run of five observations—four spectral bands and one total radiation—lasted between seven and fifteen minutes. Since the spectral bands were determined as percentages of the total, unless the sun remained constant for this length of time, accurate values would not be obtained. Very many runs were started only to be discarded due to a small cloud suddenly obscuring the sun. A certain number of runs were obtained, however, on weak sunlight, the light coming through a heavy but uniform and constant haze. This haze was quite different from formed clouds. The number of days permitting observations is shown in Table A.

TABLE A.—*Number of days permitting observations.*

Month.	Morning work.	Afternoon work.	Work throughout day.
February	4	1	1
March	6	4	4
April	9	5	4
May	7	4	3
June	5	4	3
July	3	2	0
August	8	7	4
September	3	3	1
October	3	2	1
November	5	2	0
December	7	1	0
January	5	4	4
Total	65	39	25

Quite apart from these instrumental requirements of constant clear sun it was considered advisable to limit observations to clear sunlight. The reasons for this may be quoted from the previous article on Methods.(2)

> The limitation of the method to use with cloudless sun is not regarded as being as objectionable as might first appear. The basic question which this work attempts to answer is the partial spectral composition of sunlight. If this must be limited to sunlight unfiltered by clouds, the results obtained will probably be on a better basis for comparison with results obtained on similar sunlight elsewhere in the world than if the problem were complicated by the intrusion of such factors as comparative cloudiness of different regions. The problem is one of solar radiation and not of sunshine as affected by cloudiness.

The values for Manila now reported will be of value chiefly in comparison with figures that it is hoped will be obtained elsewhere as opportunity offers.

In the later part of the year few observations were made at hours when the air mass was greater than 2.5. For air masses greater than 2.5 the quantities observed are small and the correction factors of the filters become very large and uncertain. This combination makes for too questionable accuracy and renders results of little value.

TABULATION OF RESULTS

The reported values are shown in two forms for each of the four spectral bands: as percentages of the total solar energy present (λ 290 to 1,400 millimicrons) and in microwatts per square millimeter of surface normal to the incident light. The total energy is also given in this last unit. The results are tabulated as the means for each separate month. The columns run by air mass and not by hours. All values for an air mass less than 2.0 (1.0 to 1.95) are summarized in an additional column. Beyond this, values are given for air mass 2.0 (1.95 to 2.4), 3.0 (2.5 to 3.4), 4.0 (3.5 to 4.4), and 5.0 (4.5 to 5.5). Below each value the deviation of the mean is shown, denoted by AD±.

$$AD = \frac{ad}{\sqrt{n}} \text{ where } ad = \frac{\Sigma d}{n} \text{ and}$$

d = difference between individual value and the mean

n = number of observations.

This AD value is given as a measure of the variability of the light for that particular month and air mass. In each table the mean of all the monthly values is shown for each air mass.

TABLE 1.—*290 to 310 millimicrons.*

[Percentage of total energy.]

A. MORNING SUN.

Month.	Air mass.														
	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	<2.0	2.0	3.0	4.0	5.0
February		0.051	0.054	0.032		0.032		0.034			0.040	0.026	0.017		
AD ±		0.003						0.001			0.002	0.001	0.001		
March	0.098	0.074	0.067	0.059	0.042	0.041	0.036	0.035	0.030	0.029	0.056	0.018	0.018		
AD ±		0.006	0.011	0.009	0.004	0.003			0.001		0.004	0.002			
April	0.069	0.054	0.068	0.067	0.054	0.041	0.046	0.047	0.035	0.053	0.056	0.025			
AD ±	0.006	0.004	0.010	0.007	0.006	0.005	0.007		0.003	0.001	0.006	0.001			
May	0.084	0.061	0.082	0.060	0.039	0.056		0.053	0.039		0.068	0.031	0.023		
AD ±	0.007	0.009		0.011		0.006			0.003		0.007	0.006			
June	0.078	0.060	0.053	0.049	0.038	0.052		0.026	0.048		0.059	0.028			
AD ±	0.004	0.004	0.011	0.008		0.008		0.000	0.001		0.009	0.003			
July			0.052		0.053	0.064	0.086		0.031	0.020	0.046	0.028			
AD ±			0.010		0.011						0.013	0.008			
August	0.065	0.082	0.085			0.055	0.052		0.027	0.036	0.058	0.031			
AD ±	0.008	0.012	0.009				0.010				0.012	0.006			
September	0.103	0.084	0.053	0.041			0.041				0.081	0.015			
AD ±	0.002	0.009	0.016				0.016				0.009				
October		0.073	0.066	0.054	0.058						0.067				
AD ±		0.010	0.012	0.009							0.010				
November			0.082	0.078	0.073	0.043	0.066	0.051		0.061	0.066	0.030			
AD ±				0.003			0.004	0.007			0.004	0.002			
December				0.076	0.055	0.060	0.060	0.053		0.067	0.066	0.030			
AD ±				0.003	0.001	0.006	0.002	0.003			0.003	0.005			
January			0.045	0.049	0.058	0.053	0.068	0.060		0.045	0.052	0.039			
AD ±			0.010	0.004	0.003	0.007		0.000		0.004	0.005	0.003			
M	0.083	0.067	0.064	0.057	0.052	0.050	0.050	0.045	0.035	0.044	0.060	0.027	0.020		
AD ±	0.004	0.004	0.004	0.004	0.003	0.003	0.003	0.004	0.003	0.005	0.003	0.002	0.002		

TABLE 1.—*290 to 310 millimicrons*—Continued.

B. AFTERNOON SUN.

Month.	Air mass.														
	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	<2.0	2.0	3.0	4.0	5.0
February	--------	0.053	0.045	--------	0.051	0.034	--------	--------	0.020	--------	0.043	0.020	0.020	0.006	--------
AD ±	--------	0.001	--------	--------	--------	--------	--------	--------	--------	--------	0.003	--------	--------	--------	--------
March	0.092	0.070	0.059	0.064	0.054	0.036	0.047	--------	0.029	0.060	0.062	0.027	0.020	0.016	--------
AD ±	--------	0.005	0.003	0.012	0.002	--------	--------	--------	--------	--------	0.005	0.001	0.007	0.003	--------
April	0.070	0.065	0.053	0.046	0.047	0.035	0.027	0.048	--------	--------	0.058	0.022	0.017	0.009	0.006
AD ±	0.006	0.006	--------	0.006	0.009	--------	--------	0.004	--------	--------	0.005	0.002	0.001	0.002	--------
May	0.080	0.085	0.078	0.052	0.074	--------	0.030	--------	--------	--------	0.073	0.040	0.015	0.010	--------
AD ±	0.010	0.014	0.006	0.002	--------	--------	--------	--------	--------	--------	0.009	0.001	--------	--------	--------
June	0.066	0.070	0.061	0.075	0.060	--------	0.066	--------	--------	0.043	0.065	--------	0.037	--------	--------
AD ±	0.008	0.015	0.012	0.006	0.005	--------	0.000	--------	--------	--------	0.010	--------	--------	--------	--------
July	--------	--------	0.051	--------	--------	0.055	0.030	--------	--------	--------	0.047	--------	--------	--------	--------
AD ±	--------	--------	0.001	--------	--------	--------	--------	--------	--------	--------	0.006	--------	--------	--------	--------
August	0.095	0.075	0.065	0.082	0.070	0.053	0.064	0.046	--------	--------	0.075	0.043	0.026	0.022	--------
AD ±	0.007	0.010	0.009	0.014	--------	0.010	--------	0.009	--------	--------	0.009	0.006	0.006	0.003	--------
September	0.088	0.087	--------	--------	--------	0.026	--------	--------	0.017	--------	0.065	0.015	--------	--------	--------
AD ±	0.001	0.002	--------	--------	--------	--------	--------	--------	--------	--------	0.001	--------	--------	--------	--------
October	--------	0.080	0.072	--------	0.057	--------	0.053	--------	--------	--------	0.069	0.040	--------	--------	--------
AD ±	--------	0.001	0.004	--------	--------	--------	--------	--------	--------	--------	0.003	--------	--------	--------	--------
November	--------	--------	--------	0.041	0.066	0.011	--------	--------	--------	--------	0.019	--------	--------	--------	--------
AD ±	--------	--------	--------	0.012	--------	--------	--------	--------	--------	--------	0.009	--------	--------	--------	--------
December	--------	--------	--------	0.076	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
AD ±	--------	--------	--------	0.004	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
January	--------	--------	0.048	0.052	0.042	0.051	--------	0.045	--------	--------	0.049	0.037	--------	--------	--------
AD ±	--------	--------	0.006	0.008	--------	0.009	--------	--------	--------	--------	0.007	0.012	--------	--------	--------
M	0.082	0.073	0.059	0.061	0.058	0.038	0.045	0.046	0.022	0.052	0.057	0.031	0.023	0.012	0.006
AD ±	0.003	0.003	0.003	0.004	0.003	0.004	0.005	0.001	0.003	0.005	0.004	0.003	0.003	0.002	--------

C. TOTAL DAY.

February	--------	0.052	0.050	0.032	0.051	0.033	--------	--------	--------	--------	0.043	0.029	0.018	--------	--------
AD ±	--------	0.002	0.004	--------	--------	0.001	--------	--------	--------	--------	0.003	0.003	0.001	--------	--------
March	0.095	0.072	0.063	0.062	0.047	0.040	0.042	--------	0.030	0.045	0.059	0.021	0.019	--------	--------
AD ±	0.002	0.004	0.004	0.007	0.004	0.002	0.006	--------	0.001	0.010	0.003	0.002	0.001	--------	--------
April	0.069	0.058	0.067	0.058	0.051	0.040	0.041	0.048	--------	--------	0.056	0.023	--------	--------	--------
AD ±	0.006	0.005	0.010	0.007	0.007	0.005	0.007	0.005	--------	--------	0.006	0.002	--------	--------	--------
May	0.083	0.070	0.080	0.056	0.057	--------	--------	--------	--------	--------	0.070	0.035	0.020	--------	--------
AD ±	0.008	0.010	0.008	0.007	0.010	--------	--------	--------	--------	--------	0.008	0.004	0.014	--------	--------
June	0.075	0.065	0.057	0.060	0.053	--------	--------	--------	--------	--------	0.061	--------	--------	--------	--------
AD ±	0.005	0.009	0.012	0.008	0.009	--------	--------	--------	--------	--------	0.009	--------	--------	--------	--------
July	--------	--------	0.052	--------	--------	0.060	0.033	--------	--------	--------	0.046	--------	--------	--------	--------
AD ±	--------	--------	0.007	--------	--------	0.002	0.002	--------	--------	--------	0.011	--------	--------	--------	--------
August	0.078	0.077	0.072	--------	--------	0.054	0.042	--------	--------	--------	0.036	0.037	--------	--------	--------
AD ±	0.008	0.011	0.009	--------	--------	0.010	0.010	--------	--------	--------	0.006	0.006	--------	--------	--------
September	0.096	0.068	--------	--------	--------	--------	--------	--------	--------	--------	0.071	0.015	--------	--------	--------
AD ±	0.002	0.007	--------	--------	--------	--------	--------	--------	--------	--------	0.006	--------	--------	--------	--------
October	--------	0.076	0.068	--------	0.058	--------	--------	--------	--------	--------	0.040	--------	--------	--------	--------
AD ±	--------	0.009	0.009	--------	0.001	--------	--------	--------	--------	--------	0.003	--------	--------	--------	--------
November	--------	--------	--------	0.063	0.070	0.027	--------	--------	--------	--------	--------	--------	--------	--------	--------
AD ±	--------	--------	--------	0.006	0.003	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
December	--------	--------	--------	0.076	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
AD ±	--------	--------	--------	0.003	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
January	--------	--------	0.046	0.051	0.048	0.05	--------	0.055	--------	--------	0.051	0.038	--------	--------	--------
AD ±	--------	--------	0.008	0.007	0.002	0.008	--------	0.006	--------	--------	0.006	0.006	--------	--------	--------
M	0.083	0.067	0.062	0.051	0.054	0.044	0.039	0.052	0.030	0.045	0.053	0.028	0.019	--------	--------
AD ±	0.003	0.002	0.003	0.003	0.002	0.004	0.002	0.002	0.001	0.010	0.003	0.008	0.001	--------	--------

TABLE 2.—*310 to 370 millimicrons.*

[Percentage of total energy.]

A. MORNING SUN.

Month.	Air mass.														
	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	<2.0	2.0	3.0	4.0	5.0
February	------	1.7	1.4	1.1	------	1.1	------	1.1	------	------	1.3	1.0	0.6	------	------
AD ±	------	0.04	------	------	------	------	------	0.05	------	------	0.05	0.05	0.07	------	------
March	1.8	1.7	1.6	1.5	1.4	1.1	1.5	1.2	1.0	0.9	1.4	0.8	0.5	------	------
AD ±	------	0.00	0.04	0.03	0.05	0.03	------	------	0.05	------	0.03	0.06	------	------	------
April	1.8	1.7	1.6	1.6	1.4	1.2	1.3	1.3	1.0	0.9	1.5	0.8	------	------	------
AD ±	0.04	0.03	0.04	0.03	0.04	0.10	0.17	------	0.05	0.04	0.4	0.07	------	------	------
May	2.1	1.9	1.6	1.8	1.1	1.4	------	1.1	1.2	------	1.7	0.9	0.9	------	------
AD ±	0.04	0.01	------	0.05	------	0.10	------	------	0.00	------	0.04	0.03	------	------	------
June	2.0	1.8	1.7	1.6	1.4	1.3	------	1.3	1.1	------	1.7	0.9	------	------	------
AD ±	0.03	0.03	0.06	0.05	------	0.03	------	0.02	0.05	------	0.03	0.05	------	------	------
July	------	------	1.7	------	1.5	1.3	1.4	------	1.0	1.1	1.4	0.9	------	------	------
AD ±	------	------	0.05	------	0.03	------	------	------	------	------	0.11	0.10	------	------	------
August	1.8	1.8	1.5	------	------	1.1	1.8	------	1.2	1.5	1.6	0.7	------	------	------
AD ±	0.05	0.04	0.10	------	------	------	0.10	------	------	------	0.20	0.12	------	------	------
September	1.8	1.7	1.7	1.7	------	------	1.2	------	------	------	1.7	0.9	------	------	------
AD ±	0.02	0.03	0.04	------	------	------	0.01	------	------	------	0.02	------	------	------	------
October	------	1.6	1.6	1.50	1.34	------	------	------	------	------	1.59	------	------	------	------
AD ±	------	0.01	0.01	0.04	------	------	------	------	------	------	0.01	------	------	------	------
November	------	------	1.62	1.48	1.33	1.0	1.42	1.6	------	1.34	0.12	1.0	------	------	------
AD ±	------	------	------	0.01	------	------	0.06	0.03	------	------	0.03	0.05	------	------	------
December	------	------	------	1.46	1.60	1.44	1.24	1.18	------	0.93	1.36	0.73	------	------	------
AD ±	------	------	------	0.02	0.04	0.01	0.00	0.03	------	------	0.02	0.07	------	------	------
January	------	------	1.53	1.58	1.67	1.22	1.14	1.09	------	0.92	1.83	0.66	------	------	------
AD ±	------	------	0.09	0.09	0.04	0.04	------	0.01	------	0.03	0.06	0.06	------	------	------
M	1.9	1.8	1.6	1.5	1.5	1.2	1.3	1.2	1.1	1.1	1.5	0.9	0.7	------	------
AD ±	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	------	------

B. AFTERNOON SUN.

February		1.7	1.5		1.4	1.3			1.3		1.4	0.8	0.4	0.2	
AD ±		0.04									0.03				
March	1.9	1.8	1.7	1.7	1.2	1.5	1.3		1.6	1.0	1.6	0.8	0.5	0.3	
AD ±		0.04	0.02	0.03	0.00						0.03	0.02	0.02	0.04	
April	1.8	1.7	1.5	1.5	1.3	1.2	0.9	1.1			1.6	0.8	0.5	0.3	0.2
AD ±	0.03	0.03		0.04	0.02			0.03			0.05	0.05	0.07	0.03	
May	2.1	1.9	1.7	1.7	1.3		1.4				1.8	0.9	0.7	0.5	
AD ±	0.05	0.08	0.01	0.03							0.04	0.00			
June	2.0	2.0	1.8	1.7	1.6		1.4			1.0	1.8		0.7		
AD ±	0.03	0.07	0.03	0.01	0.04		0.02				0.04				
July			1.8			1.5	1.6				1.7				
AD ±			0.10								0.11				
August	1.8	1.8	1.6	1.7	1.7	1.5	1.2	1.4			1.7	1.0	0.6	0.3	
AD ±	0.05	0.05	0.10	0.05		0.10		0.10			0.10	0.05	0.04	0.03	
September	1.8	1.7				1.4			1.2		1.6	0.9			
AD ±	0.01	0.01									0.01				
October		1.62	1.63		1.44		1.25				1.53	1.46			
AD ±		0.00	0.07								0.04				
November				1.0	1.33						1.11				
AD ±				0.10							0.16				
December				1.43											
AD ±				0.07											
January			1.45	1.58	1.36	1.40		1.66			1.53	0.79			
AD ±			0.02	0.04		0.02					0.03	0.12			
M	1.9	1.8	1.6	1.5	1.4	1.4	1.3	1.4	1.4	1.0	1.6	0.9	0.9	0.3	0.2
AD ±	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1	

TABLE 2.—*310 to 370 millimicrons*—Continued.

C. TOTAL DAY.

Month.	Air mass.														
	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	<2.0	2.0	3.0	4.0	5.0
February	------	1.7	1.5	1.1	------	1.2	------	------	------	------	1.4	0.9	0.6	------	------
AD ±	------	0.02	0.00	------	------	0.07	------	------	------	------	0.08	0.05	0.07	------	------
March	1.9	1.7	1.7	1.6	1.3	1.2	1.4	------	1.2	0.9	1.5	0.8	0.5	------	------
AD ±	0.04	0.03	0.02	0.04	0.06	0.07	0.08	------	0.10	0.03	0.03	0.04	0.03	------	------
April	1.8	1.7	1.6	1.5	1.4	1.2	1.2	1.1	------	------	1.5	1.9	------	------	------
AD ±	0.03	0.03	0.04	0.03	0.03	0.05	0.16	0.06	------	------	0.05	0.07	------	------	------
May	2.1	1.9	1.7	1.8	1.2	------	------	------	------	------	1.8	0.9	0.8	------	------
AD ±	0.04	0.01	0.02	0.03	0.01	------	------	------	------	------	0.04	0.02	0.07	------	------
June	2.0	1.9	1.7	1.6	1.6	------	------	------	------	------	1.7	------	------	------	------
AD ±	0.03	0.05	0.05	0.04	0.08	------	------	------	------	------	0.03	------	------	------	------
July	------	------	1.8	------	------	1.4	1.5	------	------	------	1.5	------	------	------	------
AD ±	------	------	0.07	------	------	0.04	0.06	------	------	------	0.12	------	------	------	------
August	1.8	1.8	1.6	------	------	1.4	1.3	------	------	------	0.8	0.8	------	------	------
AD ±	0.07	0.07	0.07	------	------	0.07	0.10	------	------	------	0.10	0.08	------	------	------
September	1.8	1.7	------	------	------	------	------	------	------	------	1.6	0.9	------	------	------
AD ±	0.02	0.02	------	------	------	------	------	------	------	------	0.02	------	------	------	------
October	------	1.64	1.63	------	1.39	------	------	------	------	------	0.91	------	------	------	------
AD ±	------	0.08	0.03	------	0.04	------	------	------	------	------	0.04	------	------	------	------
November	------	------	------	1.24	1.33	------	------	------	------	------	------	------	------	------	------
AD ±	------	------	------	0.10	0. 00	------	------	------	------	------	------	------	------	------	------
December	------	------	------	1.46	------	------	------	------	------	------	------	------	------	------	------
AD ±	------	------	------	0.02	------	------	------	------	------	------	------	------	------	------	------
January	------	------	1.50	1.74	1.37	1.28	------	1.28	------	------	1.41	0.70	------	------	------
AD ±	------	------	0.06	0.06	0.04	0.04	------	0.01	------	------	0.05	0.08	------	------	------
M	1.9	1.8	1.6	1.5	1.4	1.4	1.4	1.2	1.2	0.9	1.4	1.0	0.6	------	------
AD ±	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	------	------	0.1	0.1	0.1	------	------

TABLE 3.—*370 to 400 millimicrons.*

[Percentage of total energy.]

A. MORNING SUN.

Month.	Air mass.														
	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	< 2.0	2.0	3.0	4.0	5.0
February	......	2.9	3.0	3.0	......	2.4	......	1.9	......	......	2.8	1.9	1.5	......	......
AD ±	......	0.1	......	......	......	......	......	0.2	......	......	0.2	0.1	0.0	......	......
March	3.4	3.0	2.8	2.9	2.4	2.4	2.2	2.4	2.5	2.1	2.7	1.8	1.5	......	......
AD ±	......	0.1	0.0	0.1	0.1	0.1	......	......	0.0	......	0.1	0.0	......	......	......
April	3.3	3.0	3.0	2.0	2.7	2.6	2.2	2.4	2.2	2.8	2.8	2.1	......	......	......
AD ±	0.1	0.1	0.1	0.1	0.1	0.1	0.1	......	0.1	0.1	0.1	0.2	......	......	......
May	3.4	3.4	3.3	2.7	3.0	2.9	......	2.4	2.6	......	3.2	2.2	2.2	......	......
AD ±	0.1	0.1	......	......	......	0.1	......	......	0.0	......	0.1	0.1	......	......	......
June	3.2	3.3	3.2	3.1	3.2	2.8	......	2.8	2.4	......	2.7	2.2	......	......	......
AD ±	0.1	0.1	0.1	0.1	......	0.0	......	0.0	0.0	......	0.1	0.1	......	......	......
July	......	......	3.3	......	3.4	2.9	2.9	......	2.7	3.1	3.3	2.2	......	......	......
AD ±	......	......	0.1	......	0.1	......	......	......	......	......	0.2	0.2	......	......	......
August	3.4	3.2	3.2	......	......	2.6	2.7	......	2.5	2.6	3.1	2.0	......	......	......
AD ±	0.1	0.1	0.1	......	......	......	0.1	......	......	......	0.1	0.1	......	......	......
September	3.4	3.4	3.2	2.7	......	......	2.8	......	......	......	3.2	2.6	......	......	......
AD ±	0.1	0.0	0.1	......	......	......	0.1	......	......	......	0.1	......	......	......	......
October	......	3.3	3.3	3.0	3.0	......	......	......	......	......	3.2	......	......	......	......
AD ±	......	0.1	0.1	0.1	......	......	......	......	......	......	0.1	......	......	......	......
November	......	......	2.9	2.9	3.2	2.5	2.6	2.0	......	2.7	2.6	2.4	......	......	......
AD ±	......	......	......	0.1	......	......	0.1	0.0	......	......	0.1	0.1	......	......	......
December	......	......	......	2.7	3.1	3.0	2.7	2.4	......	2.3	2.7	1.9	......	......	......
AD ±	......	......	......	0.1	0.1	0.1	0.1	0.1	......	......	0.1	0.1	......	......	......
January	......	......	2.8	2.7	2.8	2.7	2.5	2.5	......	2.3	2.7	1.7	......	......	......
AD ±	......	......	0.1	0.2	0.1	0.1	......	0.1	......	0.1	0.1	0.2	......	......	......
M	3.3	3.2	3.1	2.6	2.9	2.7	2.6	2.4	2.5	2.5	2.9	2.1	1.7	......	......
AD ±	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	......	......

TABLE 3.—*370 to 400 millimicrons*—Continued.

B. AFTERNOON SUN.

Month.	Air mass.														
	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	<2.0	2.0	3.0	4.0	5.0
February		3.0	2.6		2.5	2.4			1.9		2.6	1.9	1.3	0.6	
AD ±		0.1									0.2				
March	3.2	3.1	2.8	2.8	2.8	2.5	2.5		1.9	2.1	2.9	0.9	1.5	0.6	
AD ±		0.1	0.1	0.1	0.0						0.1	0.0	0.0	0.0	
April	3.2	2.9	2.6	2.5	2.8	2.2	1.9	2.5			2.8	1.7	1.3	0.8	0.1
AD ±	0.1	0.1		0.2	0.2			0.1			0.1	0.1	0.1	0.1	
May	3.3	3.3	3.2	2.7	2.8		2.8				3.1	2.0	1.4	0.8	
AD ±	0.1	0.1	0.0	0.0							0.1	0.0			
June	3.4	3.4	3.3	3.2	2.8		2.8			2.6	3.2		2.1		
AD ±	0.1	0.1	0.1	0.1	0.0		0.1				0.1				
July			3.6			3.0	3.1				3.3				
AD ±			0.1								0.1				
August	3.5	3.2	3.5	3.1	2.9	2.9	2.8	2.6			3.2	2.2	1.2	1.3	
AD ±	0.0	0.1	0.1	0.0		0.0		0.1			0.1	0.0	0.2	0.2	
September	3.6	3.4				2.6			2.3		3.1	2.0			
AD ±	0.1	0.1									0.1				
October		3.3	3.4		3.2		2.4				3.2	1.9			
AD ±		0.1	0.1								0.1				
November				2.4	2.8						2.5				
AD ±				0.3							0.2				
December				2.8											
AD ±				0.1											
January			2.7	2.6	3.1	2.6		1.3			2.5	1.5			
AD ±			0.1	0.1		0.0					0.1	0.2			
M	3.4	3.2	3.1	2.8	2.9	2.6	2.6	2.1	2.0	2.4	2.9	1.8	1.5	0.8	0.1
AD ±	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.1	0.2	0.1	0.1	0.1	0.1	

C. TOTAL DAY.

February	------	3.0	2.8	------	------	2.4	------	------	------	------	2.3	1.9	1.5	------	------
AD ±	------	0.1	0.1	------	------	0.0	------	------	------	------	0.1	0.1	0.2	------	------
March	3.3	3.1	2.8	2.8	2.6	2.4	2.4	------	2.3	2.1	2.8	1.9	1.5	------	------
AD ±	0.1	0.1	0.1	0.1	0.1	0.1	0.1	------	0.2	0.0	0.0	0.1	0.1	------	------
April	3.2	3.0	2.9	2.7	2.7	2.6	2.6	2.5	------	------	2.8	1.9	------	------	------
AD ±	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	------	------	0.1	0.07	------	------	------
May	3.4	3.4	3.2	2.7	2.9	------	------	------	------	------	3.2	2.1	1.8	------	------
AD ±	0.1	0.1	0.0	0.0	0.1	------	------	------	------	------	0.1	0.1	0.3	------	------
June	3.3	3.3	3.3	3.2	2.9	------	------	------	------	------	2.9	------	------	------	------
AD ±	0.1	0.1	0.1	0.1	0.1	------	------	------	------	------	0.1	------	------	------	------
July	------	------	3.4	------	------	3.0	3.0	------	------	------	2.7	------	------	------	------
AD ±	------	------	0.1	------	------	0.1	0.1	------	------	------	0.3	------	------	------	------
August	3.4	3.2	3.4	------	------	2.8	2.7	------	------	------	2.0	2.0	------	------	------
AD ±	0.1	0.1	0.1	------	------	0.1	0.1	------	------	------	0.1	0.1	------	------	------
September	3.4	3.4	------	------	------	------	------	------	------	------	3.2	2.3	------	------	------
AD ±	0.1	0.1	------	------	------	------	------	------	------	------	0.1	0.2	------	------	------
October	------	3.3	3.3	------	3.1	------	------	------	------	------	1.9	------	------	------	------
AD ±	------	0.1	0.1	------	0.1	------	------	------	------	------	0.1	------	------	------	------
November	------	------	------	2.6	3.0	------	------	------	------	------	------	------	------	------	------
AD ±	------	------	------	0.2	0.1	------	------	------	------	------	------	------	------	------	------
December	------	------	------	2.6	------	------	------	------	------	------	------	------	------	------	------
AD ±	------	------	------	0.1	------	------	------	------	------	------	------	------	------	------	------
January	------	------	2.7	2.7	2.8	2.6	------	2.1	------	------	2.6	1.6	------	------	------
AD ±	------	------	0.1	0.1	0.1	0.1	------	0.5	------	------	0.1	0.2	------	------	------
M	3.4	3.2	3.1	2.6	2.9	2.6	2.7	2.3	2.3	2.1	2.6	2.0	1.6	------	------
AD ±	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.0	0.1	0.1	0.1	------	------

TABLE 4.—*400 to 460 millimicrons.*

[Percentage of total energy.]

A. MORNING SUN.

Month.	Air mass.														
	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	<2.0	2.0	3.0	4.0	5.0
February	------	8.7	8.1	7.8	------	7.7	------	7.1	------	------	7.8	7.3	6.8	------	------
AD ±	------	0.1	------	------	------	------	------	0.4	------	------	0.3	0.4	0.4	------	------
March	9.2	8.8	8.2	8.4	8.4	8.2	8.2	8.4	7.4	7.3	8.4	7.4	6.4	------	------
AD ±	------	0.2	0.5	0.2	0.1	0.2	------	------	0.1	------	0.2	0.2	------	------	------
April	8.9	9.0	8.4	8.6	8.4	7.8	8.2	8.9	7.9	7.7	8.5	6.8	------	------	------
AD ±	0.1	0.2	0.2	0.3	0.3	0.1	0.5	------	0.1	0.2	0.2	0.2	------	------	------
May	9.4	9.2	9.0	9.7	8.8	9.0	------	7.6	8.5	------	9.2	8.0	9.3	------	------
AD ±	0.1	0.2	------	0.0	------	0.6	------	------	0.1	------	0.2	0.3	------	------	------
June	9.4	9.2	9.0	9.3	8.8	8.4	------	8.0	7.8	------	9.2	7.5	------	------	------
AD ±	0.1	0.2	0.2	0.3	------	0.0	------	0.1	0.1	------	0.1	0.2	------	------	------
July	------	------	8.0	------	8.6	8.3	8.2	------	------	7.8	8.2	7.9	------	------	------
AD ±	------	------	0.5	------	0.2	------	------	------	------	------	0.3	0.6	------	------	------
August	9.5	9.2	8.7	------	------	8.0	8.8	------	8.1	8.3	9.0	7.7	------	------	------
AD ±	0.1	0.2	0.6	------	------	------	0.1	------	------	------	0.2	0.2	------	------	------
September	10.5	9.6	9.5	8.9	------	------	9.2	------	------	------	9.4	8.0	------	------	------
AD ±	0.1	0.2	0.1	------	------	------	0.6	------	------	------	0.2	------	------	------	------
October	------	9.3	9.3	8.8	8.0	------	------	------	------	------	9.1	------	------	------	------
AD ±	------	0.1	0.2	0.1	------	------	------	------	------	------	0.1	------	------	------	------
November	------	------	8.8	8.8	8.6	6.8	8.3	8.2	------	------	8.3	8.9	------	------	------
AD ±	------	------	------	0.3	------	------	------	0.3	------	------	0.3	0.3	------	------	------
December	------	------	------	9.3	9.2	9.5	9.2	8.3	------	9.1	9.1	8.2	------	------	------
AD ±	------	------	------	0.2	0.1	0.4	0.2	0.2	------	------	0.2	0.2	------	------	------
January	------	------	8.8	8.4	7.7	8.2	7.9	8.6	------	7.6	8.2	7.0	------	------	------
AD ±	------	------	0.5	0.3	0.5	0.2	------	0.6	------	0.1	0.4	0.3	------	------	------
M	9.5	9.1	8.7	8.8	8.6	8.2	8.4	8.1	7.9	8.0	8.7	7.7	7.5	------	------
AD ±	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.2	0.1	0.2	0.1	0.1	0.1	------	------

B. AFTERNOON SUN.

February		9.6	7.8		8.8	8.1			6.7		8.5	6.7	6.4	3.9	
AD ±		0.9									0.8				
March	8.8	9.2	8.9	8.7	8.4	8.4	9.4		7.1	7.2	8.8	7.5	6.6	5.1	
AD ±		0.2	0.4	0.1	0.2						0.5	0.1	0.1	0.1	
April	9.1	8.6	7.5	8.2	7.8	8.7	6.3	7.5			8.7	7.8	5.5	4.6	1.7
AD ±	0.2	0.1		0.2	0.1			0.1			0.2	0.6	0.5	0.5	
May	9.4	9.0	8.9	9.3	8.7		9.0				9.4	6.9	7.4	5.7	
AD ±	0.2	0.2	0.1	0.1							0.2	0.1			
June	9.1	9.4	9.4	9.4	9.1		8.6			7.3	9.1		7.4		
AD ±	0.1	0.3	0.2	0.1	0.2		0.1				0.2				
July			10.0			9.0	8.9				9.5				
AD ±			0.0								0.2				
August	9.5	9.3	9.5	9.4	10.0	8.8	7.1	8.8			9.2	6.9	7.4	6.0	
AD ±	0.2	0.3	0.2	0.2		0.1		0.1			0.2	0.2	0.3	0.2	
September	9.6	10.6				8.5			8.2		9.5	8.0			
AD ±	0.5	0.1									0.3				
October		9.7	9.4		9.6		9.6				9.5	8.5			
AD ±		0.1	0.1								0.1				
November				8.7	8.5						8.6				
AD ±				0.4							0.2				
December				9.2											
AD ±				0.4											
January			8.3	9.2	7.8	8.8		7.5			8.8	7.3			
AD ±			0.6	0.3		0.3					0.3	0.3			
M	9.3	9.4	8.9	9.0	8.8	8.6	8.4	8.0	7.8	7.3	9.1	7.4	6.8	5.1	1.7
AD ±	0.1	0.1	0.2	0.1	0.2	0.1	0.4	0.3	0.3	0.1	0.1	0.2	0.2	0.3	

TABLE 4.—*400 to 460 millimicrons*—Continued.

C. TOTAL DAY.

Month.	Air mass.														
	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	<2.0	2.0	3.0	4.0	5.0
February		9.2	8.0			7.9					8.1	7.2	6.7		
AD ±		0.5	0.1			0.1					1.4	0.3	0.3		
March	9.0	9.0	8.6	8.6	8.4	8.3	8.8		7.8	7.3	8.6	7.5	6.5		
AD ±	0.1	0.1	0.3	0.1	0.2	0.2	0.4		0.8	0.0	0.1	0.1	0.1		
April	8.9	8.9	8.3	8.4	8.2	8.0	7.7	8.0			8.5	7.4			
AD ±	0.1	0.2	0.2	0.3	0.2	0.1	0.4	0.1			0.2	0.4			
May	9.4	9.1	9.0	9.5	8.8						9.1	7.6	8.4		
AD ±	0.1	0.2	0.1	0.1	0.1						0.2	0.2	0.3		
June	9.5	9.3	9.2	9.4	9.0						9.1				
AD ±	0.1	0.2	0.2	0.2	0.4						0.1				
July			8.8			8.7	8.6				8.6				
AD ±			0.3			0.3	0.3				0.3				
August	9.5	9.3	9.2			8.5	8.2				8.5	7.3			
AD ±	0.1	0.3	0.3			0.1	0.1				0.2	0.2			
September	10.2	9.8									9.7	8.0			
AD ±	0.3	0.2									0.2				
October		9.4	9.3		8.8						7.8				
AD ±		0.1	0.2		0.6						0.3				
November				8.7	8.6						8.4				
AD ±				0.3	0.0						0.2				
December				9.3											
AD ±				0.3											
January			8.6	8.9	7.7	8.4		8.2			8.5	7.0			
AD ±			0.5	0.3	0.4	0.2		0.3			0.4	0.3			
M	9.4	9.3	8.7	9.0	8.5	8.3	8.3	8.1	7.8	7.3	8.4	7.5	7.2		
AD ±	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.3	0.0	0.1	0.1	0.3		

TABLE 5.—*290 to 310 millimicrons.*

[Microwatts per square millimeter.]

A. MORNING SUN.

Month.	Air mass.														
	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	<2.0	2.0	3.0	4.0	5.0
February		0.41	0.43	0.23		0.22		0.22			0.27	0.18	0.11		
AD ±		0.02						0.01			0.02	0.01	0.01		
March	0.87	0.63	0.54	0.46	0.32	0.28	0.28	0.26	0.21	0.20	0.45	0.12	0.11		
AD ±		0.06	0.10	0.07	0.04	0.02			0.00		0.06	0.01			
April	0.61	0.47	0.55	0.55	0.43	0.33	0.36	0.39	0.26	0.38	0.47	0.16			
AD ±	0.05	0.05	0.08	0.07	0.06	0.05	0.07		0.02	0.04	0.05	0.01			
May	0.68	0.50	0.62	0.36	0.33	0.40		0.36	0.29		0.49	0.17	0.16		
AD ±	0.05	0.06		0.01		0.03			0.04		0.05	0.03			
June	0.66	0.51	0.43	0.40	0.32	0.39		0.19	0.34		0.48	0.18			
AD ±	0.05	0.07	0.09	0.06		0.15		0.02	0.01		0.06	0.02			
July			0.45		0.43	0.53	0.30		0.23	0.15	0.38	0.18			
AD ±			0.09		0.10						0.15	0.05			
August	0.55	0.64	0.65			0.36	0.26		0.22	0.16	0.48	0.18			
AD ±	0.06	0.10	0.11				0.04				0.09	0.04			
September	0.95	0.77	0.44	0.34			0.34				0.65	0.11			
AD ±	0.04	0.08	0.15				0.14				0.09				
October		0.61	0.54	0.39	0.43						0.53				
AD ±		0.06	0.06	0.04							0.06				
November			0.63	0.51	0.62	0.26	0.57	0.26		0.37	0.45	0.22			
AD ±				0.05			0.03	0.06		0.12	0.06	0.01			
December				0.58	0.15	0.38	0.47	0.39		0.49	0.45	0.20			
AD ±				0.04	0.00	0.19	0.03	0.02			0.05	0.04			
January			0.38	0.39	0.45	0.41	0.47	0.45		0.30	0.40	0.26			
AD ±			0.08	0.06	0.04	0.06		0.02		0.01	0.06	0.02			
M	0.72	0.57	0.51	0.42	0.38	0.36	0.40	0.31	0.26	0.30	0.46	0.18	0.13		
AD ±	0.05	0.03	0.02	0.03	0.03	0.02	0.03	0.03	0.02	0.04	0.02	0.01	0.01		

TABLE 5.—*290 to 310 millimicrons*—Continued.

B. AFTERNOON SUN.

Month.	Air mass.														
	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.0	3.0	4.0	5.0
February	------	0.43	0.34	------	0.38	0.24	------	------	0.13	------	0.33	0.12	0.10	0.02	------
AD ±	------	0.01	------	------	------	------	------	------	------	------	0.01	------	------	------	------
March	0.71	0.61	0.51	0.52	0.45	0.30	0.35	------	0.21	0.43	0.52	0.18	0.11	0.07	------
AD ±	------	0.05	0.03	0.08	0.01	------	------	------	------	------	0.03	0.03	0.00	0.03	------
April	0.61	0.47	0.40	0.37	0.34	0.25	0.17	0.36	------	------	0.48	0.14	0.10	0.04	0.01
AD ±	0.07	0.06	------	0.06	0.07	------	------	0.07	------	------	0.07	0.01	0.01	0.01	------
May	0.63	0.68	0.54	0.36	0.56	------	0.23	------	------	------	0.56	0.26	0.08	0.04	------
AD ±	0.08	0.07	0.02	0.01	------	------	------	------	------	------	0.05	0.03	------	------	------
June	0.55	0.52	0.46	0.63	0.51	------	0.57	------	------	0.32	0.52	------	0.23	------	------
AD ±	0.05	0.08	0.10	0.10	0.09	------	0.02	------	------	------	0.08	------	------	------	------
July	------	------	0.67	------	------	0.21	0.24	------	------	------	0.59	------	------	------	------
AD ±	------	------	0.38	------	------	------	------	------	------	------	0.36	------	------	------	------
August	0.76	0.62	0.52	0.63	0.53	0.48	0.41	0.39	------	------	0.56	0.28	0.13	0.12	------
AD ±	0.09	0.09	0.08	0.15	------	0.09	------	0.07	------	------	0.09	0.04	0.01	0.02	------
September	0.81	0.75	------	------	------	0.18	------	------	0.10	------	0.57	0.11	------	------	------
AD ±	0.03	0.04	------	------	------	------	------	------	------	------	0.04	------	------	------	------
October	------	0.60	0.27	------	0.12	------	0.12	------	------	------	0.30	0.17	------	------	------
AD ±	------	0.10	0.05	------	------	------	------	------	------	------	0.07	0.06	------	------	------
November	------	------	------	0.30	0.44	0.64	------	------	------	------	0.42	------	------	------	------
AD ±	------	------	------	0.05	------	------	------	------	------	------	0.05	------	------	------	------
December	------	------	------	0.59	------	------	------	------	------	------	------	------	------	------	------
AD ±	------	------	------	0.03	------	------	------	------	------	------	------	------	------	------	------
January	------	------	0.41	0.42	0.36	0.40	------	0.35	------	------	0.40	0.28	------	------	------
AD ±	------	------	0.07	0.07	------	0.06	------	------	------	------	0.06	0.10	------	------	------
M	0.68	0.58	0.46	0.48	0.41	0.34	0.30	0.36	0.15	0.38	0.48	0.19	0.13	0.06	0.01
AD ±	0.03	0.03	0.03	0.04	0.03	0.05	0.04	0.01	0.02	0.04	0.03	0.02	0.02	0.01	------

C. TOTAL DAY.

February	-------	0.42	0.39	-------	-------	0.23	-------	-------	-------	-------	0.31	0.16	0.11	-------	-------
AD ±	-------	0.01	0.04	-------	-------	0.01	-------	-------	-------	-------	0.03	0.01	0.01	-------	-------
March	0.79	0.62	0.53	0.49	0.37	0.29	0.31	-------	0.21	0.32	0.48	0.14	0.11	-------	-------
AD ±	0.06	0.04	0.02	0.05	0.03	0.02	0.03	-------	0.00	0.09	0.02	0.01	0.00	-------	-------
April	0.61	0.51	0.53	0.47	0.41	0.81	0.32	0.37	-------	-------	0.47	0.15	0.13	-------	-------
AD ±	0.04	0.04	0.07	0.05	0.05	0.04	0.06	0.04	-------	-------	0.02	0.01	0.03	-------	-------
May	0.67	0.57	0.57	0.85	0.45	-------	-------	-------	-------	-------	0.54	0.24	0.12	-------	-------
AD ±	0.04	0.06	0.02	0.01	0.09	-------	-------	-------	-------	-------	0.03	0.02	0.04	-------	-------
June	0.63	0.51	0.44	0.50	0.45	-------	-------	-------	-------	-------	0.50	-------	-------	-------	-------
AD ±	0.04	0.05	0.06	0.06	0.07	-------	-------	-------	-------	-------	0.05	-------	-------	-------	-------
July	-------	-------	0.37	-------	0.43	0.57	0.27	-------	-------	-------	0.33	-------	-------	-------	-------
AD ±	-------	-------	0.05	-------	0.10	0.11	0.02	-------	-------	-------	0.06	-------	-------	-------	-------
August	0.61	0.62	0.56	-------	-------	0.44	0.26	0.39	-------	-------	0.52	0.22	0.13	-------	-------
AD ±	0.05	0.07	0.07	-------	-------	0.06	0.04	0.07	-------	-------	0.06	0.03	0.01	-------	-------
September	0.90	0.76	-------	-------	-------	-------	-------	-------	-------	-------	0.62	0.11	-------	-------	-------
AD ±	0.04	0.07	-------	-------	-------	-------	-------	-------	-------	-------	0.08	-------	-------	-------	-------
October	-------	0.61	0.41	-------	0.28	-------	-------	-------	-------	-------	0.44	-------	-------	-------	-------
AD ±	-------	0.07	0.06	-------	0.11	-------	-------	-------	-------	-------	0.07	-------	-------	-------	-------
November	-------	-------	-------	0.43	0.54	0.45	-------	-------	-------	-------	-------	-------	-------	-------	-------
AD ±	-------	-------	-------	0.05	0.07	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
December	-------	-------	-------	0.58	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
AD ±	-------	-------	-------	0.04	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
January	-------	-------	0.89	0.41	0.41	0.60	-------	0.40	-------	-------	0.40	0.27	-------	-------	-------
AD ±	-------	-------	0.08	0.07	0.04	0.06	-------	0.01	-------	-------	0.06	0.05	-------	-------	-------
M	0.70	0.58	0.47	0.46	0.42	0.34	0.29	0.39	0.21	0.82	0.43	0.21	0.12	-------	-------
AD ±	0.03	0.02	0.02	0.02	0.01	0.04	0.01	0.01	-------	-------	0.03	0.02	0.01	-------	-------

TABLE 6.—*310 to 370 millimicrons.*

[Microwatts per square millimeter.]

A. MORNING SUN.

Month.	Air mass.														
	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	<2.0	2.0	3.0	4.0	5.0
February		13.8	11.8	7.8		7.3		7.6			9.8	8.3	4.3		
AD ±		0.2						1.1			0.3	1.0	0.8		
March	16.0	14.3	13.0	11.2	10.4	7.9	11.0	8.1	7.3	6.0	11.3	5.6	2.9		
AD ±		0.5	1.1	0.5	0.4	0.2			1.1		0.5	0.6			
April	15.8	14.8	13.0	12.9	11.3	9.6	10.5	10.6	7.6	7.3	12.6	5.5			
AD ±	0.4	0.4	0.7	0.6	0.5	0.8	1.9		0.5	1.4	1.0	0.6			
May	16.9	15.5	12.4	11.7	9.2	10.5		7.6	8.4		13.0	5.8	6.0		
AD ±	0.6	0.3		1.9		1.3			0.1		0.7	0.4			
June	17.2	15.2	13.6	12.7	11.6	9.5		9.7	7.9		13.8	5.7			
AD ±	0.4	0.3	0.6	0.5		0.9		0.8	1.3		0.5	0.5			
July			13.8		12.2	10.8	11.1		7.4	7.9	11.8	5.9			
AD ±			0.6		0.8						0.7	0.6			
August	15.4	13.6	10.9			7.7	8.0		9.0	6.6	12.3	4.1			
AD ±	0.4	0.2	1.3				0.2				0.4	0.4			
September	17.1	15.7	13.4	14.1			10.1				14.7	6.7			
AD ±	0.4	0.3	0.6				0.5				0.5				
October		13.9	13.0	10.9	10.1						12.9				
AD ±		0.7	0.9	0.8							0.7				
November			12.1	8.4	11.2	5.7	11.3	3.9		9.6	8.7	6.6			
AD ±				0.9			0.1	0.0		1.4	0.6	0.7			
December				11.8	8.0	7.6	10.0	8.4		6.9	9.3	4.9			
AD ±				0.7	0.1	3.0	0.2	0.2			0.7	0.5			
January			12.9	12.7	10.3	9.0	8.4	8.1		6.3	10.2	12.2			
AD ±			1.1	0.9	0.7	0.7		1.0		0.9	0.9	0.6			
M	16.4	14.6	12.7	11.4	10.5	8.6	10.1	8.0	7.9	7.2	11.7	6.1	4.4		
AD ±	0.3	0.3	0.2	0.5	0.3	0.4	0.3	0.5	0.2	0.3	0.4	0.4	0.7		

B. AFTERNOON SUN.

February	------	13.5	11.0	------	9.9	8.9	------	------	7.2	------	10.7	5.0	2.0	0.4	------
AD ±	------	0.5	------	------	------	------	------	------	------	------	0.5	------	------	------	------
March	14.9	15.1	14.3	13.5	11.2	11.7	9.8	------	11.5	7.4	13.5	5.5	3.2	1.5	------
AD ±	------	0.4	0.2	0.5	1.5	------	------	------	------	------	0.6	0.3	0.1	0.4	------
April	15.8	14.4	11.6	11.5	10.2	7.8	5.5	8.1	------	------	12.7	5.2	3.8	1.1	0.4
AD ±	0.4	0.2	------	0.3	0.2	------	------	0.7	------	------	0.3	0.5	0.6	0.1	------
May	16.0	15.2	11.8	12.8	10.1	------	10.6	------	------	------	14.3	5.7	3.5	2.2	------
AD ±	0.6	0.4	1.1	1.7	------	------	------	------	------	------	0.8	0.1	------	------	------
June	16.7	15.6	13.2	14.1	13.8	------	11.6	------	------	7.1	14.1	------	4.2	------	------
AD ±	0.7	1.0	1.1	0.1	0.9	------	0.1	------	------	------	0.7	------	------	------	------
July	------	------	8.7	------	------	5.6	12.5	------	------	------	8.9	------	------	------	------
AD ±	------	------	1.4	------	------	------	------	------	------	------	1.4	------	------	------	------
August	14.1	15.2	12.9	12.3	11.6	14.4	8.0	11.6	------	------	12.4	8.0	3.8	1.8	------
AD ±	0.6	0.5	1.1	1.1	------	0.7	------	0.6	------	------	0.7	1.8	0.4	0.2	------
September	16.8	14.8	------	------	------	9.5	------	------	9.9	------	13.8	6.6	------	------	------
AD ±	0.1	0.4	------	------	------	------	------	------	------	------	0.3	------	------	------	------
October	------	12.2	6.3	------	3.5	------	3.0	------	------	------	6.8	3.6	------	------	------
AD ±	------	2.0	1.8	------	------	------	------	------	------	------	1.8	1.1	------	------	------
November	------	------	------	6.6	8.9	------	------	------	------	------	7.3	------	------	------	------
AD ±	------	------	------	0.7	------	------	------	------	------	------	0.7	------	------	------	------
December	------	------	------	11.1	------	------	------	------	------	------	------	------	------	------	------
AD ±	------	------	------	0.1	------	------	------	------	------	------	------	------	------	------	------
January	------	------	12.1	12.9	11.8	11.3	------	12.6	------	------	12.4	5.5	------	------	------
AD ±	------	------	0.6	0.5	------	0.2	------	------	------	------	0.5	1.1	------	------	------
M	15.4	14.4	11.3	11.6	9.0	10.2	8.8	10.8	9.5	7.3	11.5	5.6	3.4	1.4	0.4
AD ±	0.4	0.3	0.5	0.5	0.9	0.9	0.9	1.1	0.9	0.1	0.7	0.2	0.2	0.3	------

TABLE 6.—*310 to 370 millimicrons*—Continued.

C. TOTAL DAY.

Month.	Air mass.														
	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	<2.0	2.0	3.0	4.0	5.0
February	------	13.5	11.4	------	------	8.1	------	------	------	------	10.0	6.2	3.0	------	------
AD ±	------	0.3	0.3	------	------	0.6	------	------	------	------	0.7	0.7	0.6	1.0	------
March	15.5	14.8	13.6	12.4	10.7	8.9	10.4	------	8.7	6.7	12.4	5.6	3.1	------	------
AD ±	0.4	0.4	0.5	0.5	0.6	0.8	0.4	------	0.8	0.5	0.4	0.4	0.1	------	------
April	15.8	14.6	12.9	12.3	10.9	9.3	9.2	8.9	------	------	12.6	5.5	------	------	------
AD ±	0.3	0.3	0.6	0.3	0.4	0.7	1.5	0.7	------	------	0.2	0.4	------	------	------
May	16.6	15.4	12.0	12.3	9.7	------	------	------	------	------	13.7	5.8	4.8	------	------
AD ±	0.4	0.2	0.7	1.3	0.4	------	------	------	------	------	0.5	0.1	0.1	------	------
June	17.1	15.4	13.4	13.3	13.1	------	------	------	------	------	13.9	------	------	------	------
AD ±	0.4	0.4	0.6	0.3	0.5	------	------	------	------	------	0.5	------	------	------	------
July	------	------	12.3	------	------	8.2	11.8	------	------	------	10.9	------	------	------	------
AD ±	------	------	1.4	------	------	1.9	0.5	------	------	------	1.2	------	------	------	------
August	14.9	14.5	12.2	------	------	12.2	8.0	11.6	------	------	12.7	5.2	------	------	------
AD ±	0.4	0.3	0.8	------	------	2.4	0.2	0.8	------	------	0.6	0.5	------	------	------
September	16.8	15.4	------	------	------	------	------	------	------	------	14.4	6.7	------	------	------
AD ±	0.3	0.4	------	------	------	------	------	------	------	------	0.5	0.1	------	------	------
October	------	13.5	10.3	------	6.8	------	------	------	------	------	10.6	------	------	------	------
AD ±	------	0.9	1.2	------	2.4	------	------	------	------	------	1.0	------	------	------	------
November	------	------	------	7.5	10.1	------	------	------	------	------	------	------	------	------	------
AD ±	------	------	------	0.8	0.9	------	------	------	------	------	------	------	------	------	------
December	------	------	------	11.6	------	------	------	------	------	------	------	------	------	------	------
AD ±	------	------	------	0.7	------	------	------	------	------	------	------	------	------	------	------
January	------	------	12.5	12.7	10.6	9.7	------	10.3	------	------	11.1	4.8	------	------	------
AD ±	------	------	0.9	0.6	0.7	0.6	------	1.0	------	------	0.8	0.8	------	------	------
M	16.1	14.6	12.3	11.7	10.3	9.4	9.9	10.3	8.7	6.7	12.2	5.7	3.6	1.0	------
AD ±	0.3	0.2	0.2	0.5	0.5	0.4	0.6	1.0	0.8	0.8	0.4	0.2	0.5	------	------

TABLE 7.—*370 to 400 millimicrons.*

[Microwatts per square millimeter.]

A. MORNING SUN.

Month.	Air mass.														
	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	<2.0	2.0	3.0	4.0	5.0
February		24.0	23.9	21.2		16.3		13.1			18.6	13.0	10.5		
AD ±		0.6						2.5			1.7	1.2	1.9		
March	30.1	26.7	26.5	21.8	18.3	16.6	16.9	18.0	17.4	14.3	22.0	12.4	9.5		
AD ±		1.5	4.1	0.6	0.6	1.2			0.9		1.5	0.1			
April	29.1	25.8	24.1	23.5	21.4	20.2	17.7	19.8	18.0	16.6	23.6	14.2			
AD ±	0.7	1.0	1.3	1.3	1.0	0.7	0.5		1.2	3.5	1.0	2.5			
May	27.6	27.6	24.9	12.7	25.6	20.8		16.4	19.9		25.0	13.3	15.4		
AD ±	0.7	0.5				2.0			0.2		0.8	0.6			
June	27.3	27.8	25.3	25.4	26.2	20.5		25.1	16.6		25.6	14.9			
AD ±	0.9	0.7	0.4	0.5		1.0		1.1	1.4		0.8	1.0			
July			27.5		27.3	23.9	34.4		19.9	17.2	26.5	14.4			
AD ±			1.5		0.2						1.0	1.1			
August	28.5	24.9	23.4			17.0	16.1		20.2	11.5	25.8	11.1			
AD ±	0.6	0.6	1.6				0.4				0.7	0.3			
September	30.9	30.5	26.2	22.6			22.1				27.9	17.7			
AD ±	0.4	0.1	0.8				0.4				0.3				
October		27.7	26.5	21.6	21.5						25.7				
AD ±		1.5	1.0	1.4							0.5				
November			22.7	16.2	26.8	15.0	23.7	10.2		20.7	18.7	15.8			
AD ±				1.0			0.1	1.2		2.2	1.1	1.6			
December				19.9	8.3	14.5	20.6	21.2		17.1	18.1	12.8			
AD ±				1.4	0.0	5.1	0.3	2.6			1.9	0.6			
January			23.4	20.5	21.2	19.1	18.5	18.3		15.9	17.4	12.2			
AD ±			0.6	1.3	1.1	1.6		1.0		2.1	1.1	1.3			
M	28.9	27.0	24.9	20.5	21.8	18.4	21.2	17.8	18.7	15.9	23.0	13.7	11.8		
AD ±	0.6	0.5	0.4	0.8	1.3	1.0	1.4	1.2	0.5	0.9	0.9	0.4	1.4		

TABLE 7.—*370 to 400 millimicrons*—Continued.

B. AFTERNOON SUN.

Month.	Air mass.														
	1.0	**1.1**	**1.2**	**1.3**	**1.4**	**1.5**	**1.6**	**1.7**	**1.8**	**1.9**	**<2.0**	**2.0**	**3.0**	**4.0**	**5.0**
February		24.1	19.1		18.5	16.8			14.3		19.4	11.6	6.0	1.4	
AD ±		0.1									0.1				
March	24.0	26.8	23.9	23.1	22.7	20.8	18.2		13.7	15.5	23.5	12.2	7.8	3.5	
AD ±		0.9	0.6	0.8	1.1						0.8	0.5	0.0	0.4	
April	27.7	24.6	20.0	20.1	21.7	15.6	12.4	18.7			23.1	10.9	7.2	3.9	0.4
AD ±	0.9	1.0		2.1	1.6			1.6			1.4	1.0	1.0	0.4	
May	25.7	26.2	23.1	19.6	21.2		21.0				24.0	13.2	7.1	3.4	
AD ±	1.5	1.7	3.4	1.4							1.8	0.0			
June	28.5	25.4	24.2	20.2	23.5		24.7			19.5	25.5		12.7		
AD ±	0.2	0.6	2.7	2.5	0.2		0.5				1.0				
July			17.7			11.6	25.2				18.0				
AD ±			3.8								3.8				
August	27.1	25.4	27:3	21.6	21.8	26.1	17.1	21.6			24.9	15.8	10.1	6.0	
AD ±	1.4	1.0	1.4	2.6		0.4		0.4			1.3	2.5	0.6	0.4	
September	32.1	28.9				18.7			18.1		26.5	14.8			
AD ±	0.7	2.0									1.3				
October		23.8	17.6		6.4		5.5				14.1	7.6			
AD ±		3.0	6.5								4.4	2.8			
November				14.9	18.4						16.1				
AD ±				1.4							1.4				
December				21.6											
AD ±				0.5											
January			22.6	21.9	26.6	20.4		10.1			21.5	10.9			
AD ±			2.0	0.7		0.2					0.9	2.2			
M	27.5	25.7	21.7	21.6	20.1	18.6	17.8	16.8	15.2	17.5	21.5	12.1	8.5	3.6	0.4
AD ±	0.8	0.4	0.9	0.9	1.2	1.3	2.0	2.6	1.2	1.4	1.0	0.6	0.8	0.5	

C. TOTAL DAY.

February	------	24.1	21.5	------	------	16.6	------	------	------	------	19.0	12.7	8.5	------	------
AD ±	------	0.2	1.7	------	------	0.2	------	------	------	------	1.1	0.9	1.7	------	------
March	37.1	27.6	25.2	22.5	20.0	17.6	17.5	------	16.2	14.6	23.1	12.4	8.4	------	------
AD ±	0.5	0.9	1.6	0.6	1.0	1.0	0.4	------	1.0	0.2	0.7	0.2	0.4	------	------
April	28.4	25.3	23.8	22.0	21.5	19.4	16.1	19.1	------	------	23.6	12.3	10.6	------	------
AD ±	0.6	0.8	1.3	1.0	1.2	1.0	1.0	1.0	------	------	0.3	1.2	3.3	------	------
May	27.1	27.0	23.7	17.3	23.4	------	------	------	------	------	24.6	13.5	11.3	------	------
AD ±	0.6	0.6	2.0	1.8	1.6	------	------	------	------	------	0.8	0.4	3.0	------	------
June	27.7	26.7	24.8	27.3	24.4	------	------	------	------	------	25.6	------	------	------	------
AD ±	0.6	0.7	1.1	1.1	0.7	------	------	------	------	------	0.8	------	------	------	------
July	------	------	24.7	------	------	17.7	29.8	------	------	------	23.9	------	------	------	------
AD ±	------	------	2.6	------	------	4.4	3.8	------	------	------	2.4	------	------	------	------
August	27.9	25.2	25.9	------	------	23.0	16.1	------	------	------	24.5	13.4	------	------	------
AD ±	0.7	0.6	1.2	------	------	2.3	0.4	------	------	------	1.0	1.4	------	------	------
September	31.3	30.0	------	------	------	------	------	------	------	------	27.5	16.3	------	------	------
AD ±	0.5	1.4	------	------	------	------	------	------	------	------	0.5	1.0	------	------	------
October	------	26.6	22.9	------	14.0	------	------	------	------	------	21.4	------	------	------	------
AD ±	------	1.8	3.0	------	5.4	------	------	------	------	------	1.7	------	------	------	------
November	------	------	------	15.6	22.6	------	------	------	------	------	------	------	------	------	------
AD ±	------	------	------	1.2	3.0	------	------	------	------	------	------	------	------	------	------
December	------	------	------	20.3	------	------	------	------	------	------	------	------	------	------	------
AD ±	------	------	------	1.3	------	------	------	------	------	------	------	------	------	------	------
January	------	------	23.1	21.4	22.3	19.6	------	14.2	------	------	20.6	11.7	------	------	------
AD ±	------	------	1.1	0.9	1.4	1.2	------	1.0	------	------	1.0	1.6	------	------	------
M	30.1	26.6	24.0	20.9	21.3	19.0	19.9	16.6	16.2	14.6	23.4	13.2	10.2	------	------
AD ±	1.2	0.5	0.4	1.1	0.9	0.7	2.5	1.0	1.0	1.0	0.7	0.4	0.9	------	------

TABLE 8.—*400 to 460 millimicrons.*

[Microwatts per square millimeter.]

A. MORNING SUN.

Month.	Air mass.														
	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	<2.0	2.0	3.0	4.0	5.0
February	------	71	65	57	------	53	------	48	------	------	58	49	46	------	------
AD ±	------	0	------	------	------	------	------	6	------	------	5	4	6	------	------
March	82	78	60	64	66	57	64	62	52	50	64	51	89	------	------
AD ±	------	3	5	2	1	4	------	------	4	------	4	2	------	------	------
April	78	77	68	72	67	61	65	73	57	58	69	48	------	------	------
AD ±	2	2	4	4	4	8	6	------	2	11	8	5	------	------	------
May	77	78	68	47	75	67	------	52	65	------	71	51	65	------	------
AD ±	2	2	------	------	------	7	------	------	1	------	2	1	------	------	------
June	82	79	73	73	74	58	------	55	55	------	73	48	------	------	------
AD ±	1	2	4	4	------	6	------	7	5	------	3	3	------	------	------
July	------	------	72	------	70	68	70	------	------	58	73	51	------	------	------
AD ±	------	------	1	------	1	------	------	------	------	------	1	3	------	------	------
August	80	70	63	------	------	52	51	------	69	36	68	41	------	------	------
AD ±	3	3	7	------	------	------	1	------	------	------	3	3	------	------	------
September	97	88	77	81	------	------	88	------	------	------	88	58	------	------	------
AD ±	1	2	4	------	------	------	3	------	------	------	2	------	------	------	------
October	------	77	74	63	59	------	------	------	------	------	73	------	------	------	------
AD ±	------	4	6	3	------	------	------	------	------	------	4	------	------	------	------
November	------	------	67	49	73	40	70	41	------	66	55	61	------	------	------
AD ±	------	------	------	3	------	------	------	2	------	------	8	4	------	------	------
December	------	------	------	67	26	50	72	59	------	66	59	55	------	------	------
AD ±	------	------	------	6	1	20	3	3	------	------	6	2	------	------	------
January	------	------	73	65	57	60	59	63	------	55	63	55	------	------	------
AD ±	------	------	2	3	6	4	------	7	------	7	4	7	------	------	------
M	83	77	69	64	63	57	67	57	60	66	63	61	50	------	------
AD ±	2	1	1	2	3	2	3	3	3	3	2	3	6	------	------

B. AFTERNOON SUN.

February	------	77	60	------	75	57	------	------	52	------	66	41	82	11	------
AD ±	------	6	------	------	------	------	------	------	------	------	6	------	------	------	------
March	68	79	76	73	70	69	72	------	62	52	74	49	43	23	------
AD ±	------	2	4	2	7	------	------	------	------	------	8	2	4	2	------
April	80	72	57	65	60	61	40	56	------	------	69	52	31	25	5
AD ±	8	2	------	3	1	------	------	4	------	------	3	6	4	3	------
May	71	73	63	67	66	------	51	------	------	------	69	43	38	24	------
AD ±	4	5	7	4	------	------	------	------	------	------	4	1	------	------	------
June	78	74	66	76	77	------	72	------	------	54	84	------	41	------	------
AD ±	5	8	7	1	4	------	5	------	------	------	4	------	------	------	------
July	------	------	46	------	------	34	73	------	------	------	50	------	------	------	------
AD ±	------	------	6	------	------	------	------	------	------	------	6	------	------	------	------
August	76	81	75	67	64	79	46	74	------	------	65	57	44	32	------
AD ±	5	2	5	6	------	1	------	1	------	------	4	7	6	1	------
September	88	92	------	------	------	59	------	------	66	------	81	58	------	------	------
AD ±	6	3	------	------	------	------	------	------	------	------	4	------	------	------	------
October	------	72	30	------	20	------	22	------	------	------	38	81	------	------	------
AD ±	------	13	4	------	------	------	------	------	------	------	8	9	------	------	------
November	------	------	------	58	57	------	------	------	------	------	58	------	------	------	------
AD ±	------	------	------	2	------	------	------	------	------	------	2	------	------	------	------
December	------	------	------	71	------	------	------	------	------	------	------	------	------	------	------
AD ±	------	------	------	3	------	------	------	------	------	------	------	------	------	------	------
January	------	------	66	75	67	70	------	59	------	------	71	51	------	------	------
AD ±	------	------	6	2	------	1	------	------	------	------	27	4	------	------	------
M	77	78	60	69	62	61	55	63	60	53	66	48	88	23	5
AD ±	2	2	3	1	4	4	6	4	8	1	3	2	2	2	------

TABLE 8.—*400 to 460 millimicrons*—Continued.

C. TOTAL DAY.

Month.	Air mass.														
	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	<2.0	2.0	3.0	4.0	5.0
February		74	63			55					61	48	41		
AD ±		3	2			1					4	4	8		
March	75	76	68	69	66	60	68		55	51	69	51	42		
AD ±	5	2	4	2	2	3	3		4	1	1	1	3		
April	79	75	67	69	65	61	60	62			68	50			
AD ±	2	1	3	2	2	3	6	5			1	4			
May	79	76	65	61	70						71	48	52		
AD ±	2	2	4	8	8						3	2	10		
June	81	77	69	74	76						64				
AD ±	1	2	3	2	3						2				
July			62			51	72				63				
AD ±			5			12	1				12				
August	77	77	71			70	49				71	45			
AD ±	3	3	4			7	1				3	3			
September	94	89									85	58			
AD ±	2	2									3				
October		76	56		40						60				
AD ±		6	5		14						5				
November				54	65						56				
AD ±				3	5						2				
December				68											
AD ±				6											
January			71	71		63		61			66	47			
AD ±			3	2		3		7			12	6			
M	81	78	66	67	64	60	62	61	55	51	67	50	46		
AD ±	2	1	1	2	3	2	4	6	4	1	2	1	3		

TABLE 9.—*290 to 1,400 millimicrons.*

[Microwatts per square millimeter.]

A. MORNING SUN.

Month.	Air mass.														
	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	<2.0	2.0	3.0	4.0	5.0
February		815	803	722		679		664			728	678	664		
AD ±		6						61			40	33	60		
March	890	849	799	764	766	688	770	730	704	676	778	680	620		
AD ±		14	46	19	9	14			52		21	16			
April	876	857	804	813	791	756	790	824	736	726	807	689			
AD ±	11	15	34	32	31	30	17		18	89	16	50			
May	811	818	760	661	855	727		682	754		784	629	690		
AD ±	19	20		132		31			4		32	26			
June	854	843	805	825	832	697		746	700		775	665			
AD ±	7	7	9	10		68		62	54		16	14			
July			858		818	827	834		727	727	814	642			
AD ±			18		16						17	16			
August	848	766	746			655	602		797	443	750	573			
AD ±	20	20	52				25				24	29			
September	919	913	812	820			804				870	729			
AD ±	7	3	40				17				15				
October		839	802	718	736						802				
AD ±		46	49	23							44				
November			770	627	848	662	860	603		656	704	556			
AD ±				66			4	23		36	38	76			
December				738	275	512	777	729		736	665	658			
AD ±				40	7	194	14	2			48	13			
January			829	786	756	734	749	785		689	764	658			
AD ±			22	18	22	36		29		67	28	23			
M	867	837	797	747	708	694	774	714	736	665	778	652	658		
AD ±	12	8	6	17	43	17	18	17	10	30	11	11			

TABLE 9.—*290 to 1,400 millimicrons*—Continued.

B. AFTERNOON SUN.

Month.	Air mass.														
	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	<2.0	2.0	3.0	4.0	5.0
February	------	802	730	------	785	700	------	------	665	------	739	612	487	270	------
AD ±	------	16	------	------	------	------	------	------	------	------	16	------	------	------	------
March	770	866	860	831	821	820	816	------	714	717	835	650	562	447	------
AD ±	------	8	8	19	33	------	------	------	------	------	10	16	4	17	------
April	869	835	756	781	774	700	637	746	------	------	773	641	543	468	240
AD ±	13	15	------	20	16	------	------	24	------	------	16	27	28	16	------
May	775	807	716	720	755	------	752	------	------	------	764	657	514	413	------
AD ±	41	29	86	70	------	------	------	------	------	------	48	2	------	------	------
June	842	784	734	849	839	------	860	------	------	745	806	------	616	------	------
AD ±	30	26	75	5	11	------	24	------	------	------	32	------	------	------	------
July	------	------	481	------	------	382	815	------	------	------	540	------	------	------	------
AD ±	------	------	100	------	------	------	------	------	------	------	100	------	------	------	------
August	794	804	811	733	753	895	641	850	------	------	798	694	593	526	------
AD ±	36	29	51	70	------	14	------	19	------	------	38	79	100	27	------
September	913	864	------	------	------	702	------	------	804	------	843	745	------	------	------
AD ±	9	86	------	------	------	------	------	------	------	------	22	------	------	------	------
October	------	744	374	------	212	------	234	------	------	------	423	398	------	------	------
AD ±	------	123	91	------	------	------	------	------	------	------	102	130	------	------	------
November	------	------	------	803	658	568	------	------	------	------	708	------	------	------	------
AD ±	------	------	------	41	------	------	------	------	------	------	47	------	------	------	------
December	------	------	------	773	------	------	------	------	------	------	------	------	------	------	------
AD ±	------	------	------	2	------	------	------	------	------	------	------	------	------	------	------
January	------	------	827	817	260	794	------	775	------	------	818	710	------	------	------
AD ±	------	------	80	15	------	18	------	------	------	------	13	29	------	------	------
M	827	814	676	790	645	697	679	757	712	731	732	638	553	425	240
AD ±	20	11	44	13	61	39	57	24	27	10	29	24	15	80	------

C. TOTAL DAY.

February		804	767			690					733	661	598		
AD ±		9	26			7					18	25	76		
March	830	859	830	797	788	721	793		713	697	805	670	581		
AD ±	43	8	22	17	15	25	16		33	15	9	11	15		
April	873	849	800	799	798	763	752	772			816	662			
AD ±	9	11	26	20	17	30	25	23			6	28			
May	800	852	730	691	805						723	640	602		
AD ±	16	5	52	69	29						20	12	63		
June	852	816	769	834	837						808				
AD ±	9	14	80	8	7						15				
July			707			605	825				729				
AD ±			83			160	7				60				
August	825	790	789			815	630				804	621			
AD ±	19	21	41			43					26	29			
September	917	897									863	737			
AD ±	7	11									17	6			
October		815	630		474						660				
AD ±		59	64		187						62				
November				710	753	615					706				
AD ±				58	68	33					42				
December				745											
AD ±				36											
January			828	806	860	753		755			787	678			
AD ±			25	16		31					22	25			
M	860	835	761	767	759	666	728	778	713	697	767	667	594		
AD ±	14	11	20	18	31	28	71		33	15	15	9	5		

DISCUSSION

On examining the tables of results the most striking feature is the absence of a marked peak of values such as has been found for June and adjacent months by other observers in more northerly latitudes. The monthly curve of values is quite flat. Several factors contribute to this uniformity of radiation throughout the year. Due to the low latitude, the air mass tends to remain at low values for a greater portion of the day, even during the "winter" months. Further, in contrast to other places which have been studied, the months of November to February in Manila usually give the best weather of the year. Even in 1932, when the weather was unusually cloudy, those days not markedly cloudy were clear and sparkling. On the other hand, the "summer" months which show maximum values in the United States fall in the rainy season in Manila when, even if the sun appears clear, there is apt to be a visible haziness even though this be sufficiently uniform to permit observations.

The chief value of a report of this nature must be for purposes of comparison with similar work in other places. Unfortunately, such work giving data susceptible of comparison with the present values is very scarce up to now and even of this not much is available here in the Philippines. The figures reported on work done by photochemical methods are not reducible to energy units. Indeed, for the most part, comparison of the reports of different workers with even similar photochemical methods appears difficult if not impossible. Certainly it requires more exactly defined working conditions and data on instruments used than have been given in any such work so far seen. And to attempt to compare work reported in milligrams of oxalic acid decomposed with work based on time of fading of dyes is beyond the writer.

If the radiometric program adopted at the II^{e} Congress International de La Lumiere as reported by Coblentz(3) can be carried out, comparable values may, in time, become available from widely distant regions. This program is based on the use of thermopile methods and contemplates three standard glasses being adopted for filters by all workers.

For the spectral regions λ 310 to 370, λ 370 to 400 and λ 400 to 460 millimicrons, the only figures available to the writer for comparison are those obtained by him in Baguio, Mountain Province, P. I., as reported previously.(4) The values now reported are placed on record in the hope that the writer and other workers may be able to obtain values for comparison from other localities in the future.

For the band λ 290 to 310 millimicrons, a few figures are available for comparison. This band comprises the so-called Vital U. V. in which so much interest has been shown of late. Mayerson and Laurens(5) have recently published results obtained in New Orleans, by a thermopile-filter method. Coblentz, Stair, and Hogue(6, 7) have published results obtained in Washington, likewise by a thermopile-filter method. While the methods used by these workers and by the writer are similar, the filters used to determine the spectral band were of different glass in each case. Hence the exact limits of the bands reported differ. The limiting wave length between the first two spectral bands used by the writer is 310 millimicrons, while the other workers quoted have taken 313 millimicrons as the limit. Window glass filter No. 30 here used to determine the upper limit of the first band showed perceptible transmission of the strong mercury line λ 313. Hence its zero cut-off was taken at λ 310. However, the amount of energy in sunlight lying between these two limits is small. Furthermore, any difference would be added to the band λ 290 to 313 which is of chief interest for comparison with the results of others. Hence in these comparisons, since the Manila figures are usually the larger, any discrepancies would only intensify the dissimilarity of the sunlight in Manila and elsewhere. However, these differences are believed to be of small magnitude. The values obtained by these workers in New Orleans and Washington are compared with the present Manila figures in Tables 10 and 11.

Values have been reduced to microwatts per square millimeter as used in the present report. Air masses for New Orleans have been calculated for the 15th day of each month.

Table 10 presents the figures for the three cities on a basis of 10 a. m. The approximate air masses at 10 a. m. for the three places are shown. In the winter months an explanation of the greater solar energy in Manila is readily found in the much lower air mass at 10 a. m. than in the northern cities. For the summer months, in which the air masses are nearly the same at 10 a. m., the solar energy is nearly the same in New Orleans and Manila. On the other hand, the Washington values are noticeably greater.

TABLE 10.—*Energy at 10 a. m. in band λ 290 to 310 millimicrons.*

Month.	Manila.		New Orleans. (5)		Washington. (6) (7)	
	Air mass.	Microwatts per mm².	Air mass.	Microwatts per mm².	Air mass.	Microwatts per mm².
January	1.5	0.41	2.0	0.17	----------	----------
February	1.3	0.23	1.7	0.15	1.75	0.33
March	1.2	0.54	1.4	0.28	----------	----------
April	1.1	0.47	1.2	0.36	----------	----------
May	1.1	0.50	1.1	0.36	----------	----------
June	1.1	0.51	1.1	0.50	1.2	0.60 to 0.80
July	1.2	0.45	1.2	0.45	----------	----------
August	1.2	0.65	1.2	0.46	----------	----------
September	1.2	0.44	1.3	0.32	----------	----------
October	1.2	0.52	1.4	0.26	----------	----------
November	1.3	0.51	1.7	0.20	*2.4	0.08 to 0.22
December	1.6	0.47	2.1	0.13		

* Mean.

TABLE 11.—*Energy for same air mass in band λ 290 to 310 millimicrons.*

Month.	Air mass.	New Orleans. (5)		Manila.	Air mass.	Washington. (6) (7)	Manila.
		1930	1931	1932		1930	1932
		Microwatts per mm².				*Microwatts per mm².*	
January	2.0	0.18	0.16	0.26	--------	--------	--------
February	1.7	0.15	0.14	0.22	--------	--------	--------
March	1.4	0.27	0.28	0.32	--------	--------	--------
April	1.2	0.37	0.34	0.55	--------	--------	--------
May	1.1	0.39	0.32	0.50	--------	--------	--------
June	1.1	0.59	0.40	0.51	1.1 1.2	0.90 0.60 to 0.80	0.51 0.43
July	1.2	--------	0.45	0.46	1.2	0.57	0.45
August	1.2	0.40	0.52	0.65	--------	--------	--------
September	1.3	0.32	--------	0.34	--------	--------	--------
October	1.4	0.26	0.26	0.43	--------	--------	--------
November	1.7	0.20	0.19	0.26	--------	--------	--------
December	2.1	0.13	--------	0.20	--------	--------	--------

In Table 11 the Manila values are taken for that same air mass for the month as obtained in New Orleans at 10 a. m. Most of the Manila figures are larger than those for New Orleans. The Washington figures are mostly decidedly higher than those for Manila. Whether this is due to the small number of the Washington observations or to a fundamental difference in the filters and their reduction factors used cannot be said at present. Since single values have been obtained in Manila larger than the Washington values, the writer is inclined to attribute part at least of the difference to the small number of Washington observations available.

MORNING-AFTERNOON RATIO OF ERYTHEMIC LIGHT

There is a very common impression in Manila that the morning sunlight will produce a marked sunburn with short exposure, while the afternoon sunlight rarely burns. Golfers, tennis players and swimmers, who are customarily exposed to the afternoon sun with a resultant tan of moderate degree, frequently report moderate to painful degrees of erythema from exposure to morning sunlight. To examine this question the ratios of the microwatt values for the morning and afternoon sun have to be computed for the band λ 290 to 310 millimicrons. This band contains the sharply defined maximum of the erythemic energy at λ 299 millimicrons.(8) For comparison, the ratios of the yearly means for each air mass were computed in three ways, as follows:

(*a*) The ratio of the a. m. to p. m. means.

(*b*) The ratio of these same means but with the AD of the a. m. value *added* and the AD of the p. m. value *subtracted*. This gives the maximum probable ratio.

(*c*) The same ratio but with the AD of the a. m. value *subtracted* and the AD of the p. m. value *added*. This gives the minimum probable value.

The results are given in Table 12.

TABLE 12.—*Ratio of morning ultraviolet to afternoon ultraviolet.*

Air mass.	Wave lengths 290–310 millimicrons.		
	A. M./P. M.	A. M.+AD/P. M.—AD.	A. M.—AD/P. M.+AD.
1.0	1.06	1.15	0.97
1.1	0.98	1.09	0.89
1.2	1.11	1.23	1.00
1.3	0.88	1.02	0.75
1.4	0.93	1.08	0.80
1.5	1.06	1.31	0.87
1.6	1.33	1.65	1.09
1.7	0.86	0.97	0.88
1.8	1.73	2.13	1.41
1.9	0.79	1.00	0.62
Less than 2.0	0.96	1.07	0.86
2.0	0.95	1.12	0.81
3.0	1.00	1.28	0.80
Mean	1.04±.04	1.24±.06	0.98±.05
Mean without air mass 1.8	0.99±.03	1.16±.04	0.86±.03

While this table does show some high ratios, these occur irregularly and in the midst of low ratios. The very high ratios for air mass 1.8 are considered to be entirely accidental, being preceded and followed by very low ratios, and to be due to the fact that the p. m. values for this air mass are based on figures for three months only, each of these monthly values comprising only a single instrumental run each. However, even if these high ratios be retained, the resulting mean ratios are too near unity to be regarded as showing sufficient excess ultraviolet in the morning sunlight to explain the popular belief, the maximum mean ratio obtained being 1.30 (1.24+0.06). The most probable explanation of the greater frequency of sunburn in the morning appears to be the hours of exercise customary in Manila. Morning tennis, golf or swimming usually occur between 9 a. m. and noon, when the air mass is less than 1.5. In contrast to this, the afternoon exercise is usually taken after 3 p. m., by which time the air mass is greater than 1.5. Coblentz and his associates (8) give 500,000 ergs per square centimeter as the minimum erythemic dose for monochromatic radiation of λ 297 millimicrons. From tables 5–A and 5–B the mean radiation of λ 290 to 310 millimicrons for a. m. air mass less than 1.5 is 0.52 microwatts per square millimeter, and for p. m. air mass 1.5 to 2.0, 24 microwatts per square millimeter.

These give respective exposure times for minimum erythema reactions of $\frac{5 \times 10^3 \text{ ergs}}{\text{mm}^2} \times \frac{10^{-7} \text{ joule}}{\text{erg}} \times \frac{1 \text{ watt second}}{\text{joule}} \times \frac{1 \text{ mm}^2}{0.52 \times 10^{-6} \text{ watts}} = 1000 \text{ sec.} = 17$ minutes for the customary morning exercise time and $\frac{5 \times 10^3 \text{ ergs}}{\text{mm}^2} \times \frac{10^{-7} \text{ joule}}{\text{erg}} \times \frac{1 \text{ watt second}}{\text{joule}} \times \frac{1 \text{ mm}^2}{0.24 \times 10^{-6} \text{ watts}} = 35$ minutes for the afternoon.

The ratio of $\frac{35 \text{ p. m. minutes}}{\text{a. m. minutes}}$ or, approximately 2, seems to make the difference in air mass for the respective exercise times a more adequate explanation of the popular belief than any essential difference in the morning and afternoon light for the same air mass.

ANTIRACHITIC EFFICIENCY OF MANILA SUNLIGHT

Mayerson and Laurens, (5) in New Orleans, found the maximum daily solar radiation of wave length less than 313 necessary to prevent rickets in rats to be 0.002 gram calories per square centimeter. This is equal to 140 microwatt minutes per square centimeter or 1.4 microwatt minutes per square millimeter.

The minimum value for this protective spectral band found in Manila was 0.12 microwatts per square millimeter (October, air mass 1.6, 3.30 p. m.). If we assume that the values for rats may be applied to humans, particularly to brown-skinned Filipinos, it appears that about 15 minutes' exposure of the entire body surface to sunlight even this late in the day should prevent rickets, while at noon, when the average value of 0.70 microwatts per square millimeter was found, a two-minute exposure should suffice for protection. When the scanty clothing of the children in Manila and their constant exposure to sunlight in all months of the year is remembered, the above figures seem adequate to explain the rarity of rickets in Manila.

PHOTOGRAPHIC EFFICIENCY OF MANILA SUNLIGHT

It is usually surprising to newcomers to Manila to find that photographic exposures must be from 1.5 to 2 times the normal exposure in more northerly places. From conversations and other reports(9) it appears this holds true for elsewhere in the Tropics. While all four of the spectral bands studied have intense photographic action, it is probable that only the one limited by λ 400 to 460 millimicrons is transmitted by photographic lenses to a sufficient degree to be of importance photographically.

No figures for this spectral band from outside the Tropics are available to the writer for comparison with the Manila figures. However, as previously reported,(4) the writer has obtained data on the sunlight at Baguio, Mountain Province, P. I. This is in the mountains of northern Luzon, some 160 miles north of Manila, 16° 24′ north latitude and 4,800 feet above sea level. This, of course, is very close to Manila as far as tropical location, but the altitude gives it a climate much more temperate. Adequate photographic exposures in Baguio are practically the same as in the States, and negatives taken there with the same exposures as are needed in Manila are overexposed.

Table 14 gives the ratios Baguio to Manila of the energy in the spectral band λ 400 to 460 millimicrons arranged by air mass. Two ratios are given, namely:

(*a*) The ratio of the Baguio light in January, 1932, to the Manila light in December, 1931;(4)

(*b*) The ratio of the Baguio light in January, 1932, to the yearly means of Manila light, February, 1932, to January, 1933. The comparison is made under two heads; namely, percentages and microwatts per square millimeter and for morning and afternoon separately.

TABLE 14.—*Ratio of solar energy of λ 400 to 460 millimicrons in Baguio and Manila, P. I.*

PERCENTAGES OF TOTAL SOLAR ENERGY.

Period.	Air mass.											
	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	3.0	4.0	Mean.
	Morning sun.											
Jan. 1932 to Dec. 1931	1.0	0.9	1.0	0.8	1.0	0.9	1.0	1.0	1.0	1.2	-----	1.0
Jan. 1932 to year 1932	1.09	1.01	1.02	1.04	1.02	1.09	1.01	1.16	-----	-----	-----	1.06
	Afternoon sun.											
Jan. 1932 to Dec. 1931	0.8	1.2	0.9	0.8	-----	1.0	-----	-----	0.9	1.0	0.9	0.9
Jan. 1932 to year 1932	1.03	0.97	0.97	1.00	1.02	1.03	1.15	-----	-----	-----	-----	1.03

MICROWATTS PER SQUARE MILLIMETER.

	Morning sun.											
Jan. 1932 to Dec. 1931	1.2	1.1	1.2	1.0	1.3	1.2	1.2	1.8	1.2	2.3	-----	1.3
Jan. 1932 to year 1932	1.4	1.4	1.4	1.5	1.3	1.5	1.3	1.6	-----	-----	-----	1.4
	Afternoon sun.											
Jan. 1932 to Dec. 1931	1.0	1.1	1.2	1.1	-----	1.1	-----	-----	1.3	1.4	1.1	1.2
Jan. 1932 to year 1932	1.6	1.2	1.4	1.4	1.5	1.3	1.3	-----	-----	-----	-----	1.4

The percentages of energy in this band do not differ greatly in the two places. The greatest difference found gave the greatest percentage of the light to Manila. However, when the absolute amounts of energy present were compared there was about one-third more of this photographically active light present in Baguio than in Manila. Hence it would appear from this meager data that the necessary increase in exposure in Manila is due not so much to a qualitative photographic difference in the light but to a lower total intensity. This is strikingly at variance with the visual effect of tropical sunlight, a light so intense visually as to hurt the eyes, yet weak photographically. The quantitative difference in the light of about one-third falls somewhat short of the necessary increase of photographic exposure. It may be that the mere increase in altitude of Baguio does not have the same effect on the light as does change to a more northern latitude even if the photographic exposure does become normal.

CONCLUSIONS

Due to the lack of more extensive data for comparison, only the following conclusions can be drawn from the material here presented.

1. The solar ultraviolet energy of λ 290 to 310 millimicrons is greater at 10 a. m. in Manila than in New Orleans, except during the months of June and July. This is due to the lesser air mass through which the light is filtered in Manila at the same time of day. The excess energy found in Manila is roughly proportionate to this difference in air mass.
2. For equal air mass the solar ultraviolet energy in Manila is slightly greater than in New Orleans. This excess is so slight that it is probably an accidental variation due to the smallness of sample in both cases. The same explanation is true of values in Washington, D. C., compared with Manila.
3. The popular belief that the morning sun in Manila will cause sunburn more readily than the afternoon sun is attributed to the fact that the customary hours of exposure in the afternoon are to sunlight filtered through a greater air mass and not to any real difference of the light in morning and afternoon at times equally distant from midday.
4. The antirachitic efficiency of Manila sun is such that fifteen minutes' daily exposure of the entire skin surface to sunlight in October at 3.30 p. m. or two minutes' similar exposure at noon throughout the year should protect against rickets.
5. The longer photographic exposures found necessary in Manila are partially explained by a deficiency in solar energy of λ 400 to 460 millimicrons as compared with solar energy of the same wave lengths found in Baguio, Philippine Islands, at 4,800 feet above sea level. This deficiency, as far only as these two places are concerned, is due more to a quantitative deficiency of total sunlight received than to any qualitative difference in this spectral region.

ACKNOWLEDGMENT

To the kindly personal encouragement and official support in this work of the Department Surgeons, Philippine Department, United States Army, Colonel Henry H. Rutherford, Medical Corps, and Colonel Kent Nelson, Medical Corps, and of the Presidents of the United States Army Medical Department Research Board, Major Rufus L. Holt, Medical Corps, and Major Seymour C. Schwartz, Medical Corps, the writer is greatly indebted. He is very grateful to the Reverend Miguel Selga, S. J., director of the Philippine Weather Bureau, for placing all the facilities of the Weather Bureau at his disposal, especially for giving him a suitable place for the instrumental observations and for a great deal of valuable help and advice on matters of theory. Finally, the writer would acknowledge a large debt of gratitude to Pvt. First Class Gervacio R. Sales, Medical Department, Philippine Scouts. To his patient and painstaking handling of the thermopile in making the observations, exposed for long hours to the full heat of the sun, this work owes all it may have accomplished. In truth, he has borne the heat and burden of the day.

REFERENCES CITED

1. FLEMING, WM. D. Solar ultraviolet radiometry: I, The ultraviolet limit of tropical sunlight. Philip. Journ. Sci. 50 No. 2 (1933).
2. FLEMING, WM. D. Solar ultraviolet radiometry: II, Instruments and methods. Philip. Journ. Sci. 50 No. 3 (1933).
3. COBLENTZ, W. W. Science (Nov. 4, 1932).
4. FLEMING, WM. D. Solar ultraviolet radiometry: III, Comparative values for Manila and Baguio, Philippine Islands. Philip. Journ. Sci. 51 No. 1 (1933).
5. MAYERSON, H. S., and H. LAURENS. Am. Journ. Physiology 102 2 (Nov., 1932).
6. COBLENTZ, W. W., and R. STAIR. Bur. Stand. Journ. Research 6 (June 6, 1931).
7. COBLENTZ, W. W., R. STAIR, and J. M. HOGUE. Bur. Stand. Journ. Research 7 4 (Oct., 1931).
8. COBLENTZ, W. W., R. STAIR, and J. M. HOGUE. Proc. Nat. Acad. Sci. 17 6 (June, 1931).
9. BOEREMA, J., and M. P. VRIJ. Ultraviolet in tropical sunlight. Proc. Fourth Pacific Science Congress, Java (1929).

ABSTRACT

Solar energy values for three spectral regions in the ultraviolet and one region in the violet are reported for Manila, Philippine Islands, for a twelve-month period.